US009223323B2

(12) **United States Patent**
Matas et al.

(10) **Patent No.: US 9,223,323 B2**
(45) **Date of Patent: Dec. 29, 2015**

(54) **USER FRIENDLY INTERFACE FOR CONTROL UNIT**

(75) Inventors: **Michael James Matas**, San Francisco, CA (US); **David Sloo**, Menlo Park, CA (US); **Michael Plitkins**, Berkeley, CA (US); **Anthony Michael Fadell**, Portola Valley, CA (US); **Matthew Lee Rogers**, Los Gatos, CA (US); **John Benjamin Filson**, Mountain View, CA (US); **Brian Huppi**, San Francisco, CA (US); **Fred Bould**, Menlo Park, CA (US)

(73) Assignee: **Google Inc.**, Mountain View, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 238 days.

(21) Appl. No.: **13/033,573**

(22) Filed: **Feb. 23, 2011**
(65) **Prior Publication Data**

US 2012/0130546 A1 May 24, 2012
Related U.S. Application Data

(60) Provisional application No. 61/415,771, filed on Nov. 19, 2010, provisional application No. 61/429,093, filed on Dec. 31, 2010.

(51) **Int. Cl.**
G05B 13/00 (2006.01)
G05D 23/19 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G05D 23/19*** (2013.01); ***F24D 19/10*** (2013.01); ***F24D 19/1084*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC F24F 11/00
USPC 700/276
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,558,648 A 6/1951 Warner
3,991,357 A 11/1976 Kaminski
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2202008 2/2000
DE 19609390 A1 9/1997
(Continued)

OTHER PUBLICATIONS

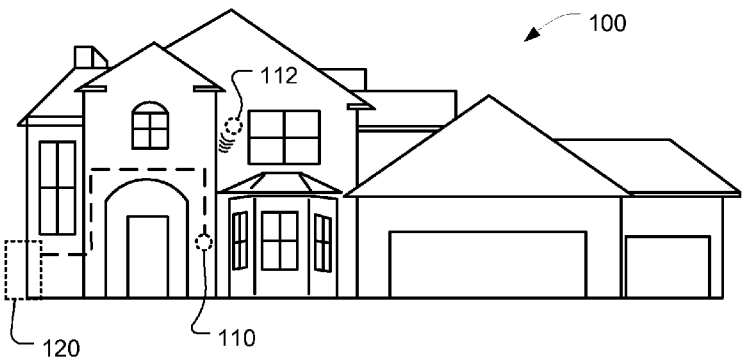
Energy Joule, Ambient Devices, 2011, [retrieved on Aug. 1, 2012]. Retrieved from: http://web.archive.org/web/20110723210421/http://www.ambientdevices.com/products/energyjoule.html, 3 pages.
(Continued)

Primary Examiner — Robert Fennema
Assistant Examiner — Anthony Whittington
(74) *Attorney, Agent, or Firm* — Kilpatrick Townsend & Stockton LLP

(57) **ABSTRACT**

A user-friendly programmable thermostat is described that includes a circular body having a large central display surrounded by a ring that can be rotated an pressed inward by a user so as to receive user input in a simple elegant fashion. Different colors can be displayed to the user to indicate currently active HVAC functions, and different shades of colors can be displayed to a user to indicate an estimated amount of time and/or energy for reaching a target temperature. The thermostat is wall mountable and is made up of a head unit removeably mounted to a backplate. A locking mechanism can be provided so as to increase security against unauthorized removal of the head unit. The backplate can be adapted to be mounted on a wall so as to be level, for example by including a bubble level on the backplate. One or more vents are preferably located on the sides of the body, such as in a gap beneath the translatably mounted ring, and/or in a gap between the head unit and the backplate. The target temperature for the device can be altered in response to sensing rotation of the rotating ring, and the programmed schedule can be displayed to and altered by the user in response to sensing rotation of the ring and the translational movement of the ring. Historical information such as temperature and cost information can be displayed to a user in response to sensing rotating of the rotating ring. One or more device settings can be displayed to and edited by a user in response to sensing rotating of the rotating member and the translational movement. According to some embodiments, text characters can be entered by the user.

20 Claims, 20 Drawing Sheets



(51) **Int. Cl.**

F24F 11/00	(2006.01)
F24D 19/10	(2006.01)
H04W 4/00	(2009.01)

(52) **U.S. Cl.**

CPC ***F24F 11/0009*** (2013.01); ***F24F 11/0012*** (2013.01); ***G05D 23/1902*** (2013.01); ***G05D 23/1917*** (2013.01); ***H04W 4/005*** (2013.01); *F24F 2011/0068* (2013.01); *F24F 2011/0073* (2013.01); *Y10T 29/49826* (2015.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,223,831	A	9/1980	Szarka
4,316,577	A	2/1982	Adams et al.
4,335,847	A	6/1982	Levine
4,408,711	A	10/1983	Levine
4,613,139	A	9/1986	Robinson, II
4,615,380	A	10/1986	Beckey
4,621,336	A	11/1986	Brown
4,674,027	A	6/1987	Beckey
4,685,614	A	8/1987	Levine
4,751,961	A	6/1988	Levine et al.
4,768,706	A	9/1988	Parfitt
4,847,781	A	7/1989	Brown, III et al.
4,897,798	A	1/1990	Cler
4,971,136	A	11/1990	Mathur et al.
4,997,029	A	3/1991	Otsuka et al.
5,005,365	A	4/1991	Lynch
D321,903	S	11/1991	Chepaitis
5,065,813	A	11/1991	Berkeley et al.
5,088,645	A	2/1992	Bell
5,115,967	A	5/1992	Wedekind
5,211,332	A	5/1993	Adams
5,224,648	A	7/1993	Simon et al.
5,224,649	A	7/1993	Brown et al.
5,240,178	A	8/1993	Dewolf et al.
5,244,146	A	9/1993	Jefferson et al.
D341,848	S	11/1993	Bigelow et al.
5,294,047	A	3/1994	Schwer et al.
5,303,612	A	4/1994	Odom et al.
5,395,042	A	3/1995	Riley et al.
5,415,346	A	5/1995	Bishop
5,460,327	A	10/1995	Hill et al.
5,462,225	A	10/1995	Massara et al.
5,476,221	A	12/1995	Seymour
5,482,209	A	1/1996	Cochran et al.
5,485,954	A	1/1996	Guy et al.
5,499,196	A	3/1996	Pacheco
5,544,036	A	8/1996	Brown, Jr. et al.
5,555,927	A	9/1996	Shah
5,603,451	A	2/1997	Helander et al.
5,611,484	A	3/1997	Uhrich
5,627,531	A	5/1997	Posso et al.
5,673,850	A	10/1997	Uptegraph
5,761,083	A	6/1998	Brown, Jr. et al.
D396,488	S	7/1998	Kunkler
5,779,143	A	7/1998	Michaud et al.
5,782,296	A	7/1998	Mehta
5,808,294	A	9/1998	Neumann
5,808,602	A	9/1998	Sellers
5,816,491	A	10/1998	Berkeley et al.
5,902,183	A	5/1999	D'Souza
5,909,378	A	6/1999	De Milleville
5,918,474	A	7/1999	Khanpara et al.
5,924,486	A	7/1999	Ehlers et al.
5,931,378	A	8/1999	Schramm
5,959,621	A	9/1999	Nawaz et al.
5,973,662	A	10/1999	Singers et al.
5,977,964	A	11/1999	Williams et al.
6,020,881	A	2/2000	Naughton et al.
6,032,867	A	3/2000	Dushane et al.
6,062,482	A	5/2000	Gauthier et al.
6,066,843	A	5/2000	Scheremeta
D428,399	S	7/2000	Kahn et al.
6,095,427	A	8/2000	Hoium et al.
6,098,893	A	8/2000	Berglund et al.
6,122,603	A	9/2000	Budike, Jr.
6,164,374	A	12/2000	Rhodes et al.
6,206,295	B1	3/2001	LaCoste
6,211,921	B1	4/2001	Cherian et al.
6,213,404	B1	4/2001	Dushane et al.
6,216,956	B1	4/2001	Ehlers et al.
6,286,764	B1	9/2001	Garvey et al.
6,298,285	B1	10/2001	Addink et al.
6,311,105	B1	10/2001	Budike, Jr.
D450,059	S	11/2001	Itou
6,318,639	B1	11/2001	Toth
6,349,883	B1	2/2002	Simmons et al.
6,351,693	B1	2/2002	Monie et al.
6,356,204	B1	3/2002	Guindi et al.
6,370,894	B1	4/2002	Thompson et al.
6,415,205	B1	7/2002	Myron et al.
6,453,687	B2	9/2002	Sharood et al.
D464,660	S	10/2002	Weng et al.
6,478,233	B1	11/2002	Shah
6,502,758	B2	1/2003	Cottrell
6,513,723	B1	2/2003	Mueller et al.
6,519,509	B1	2/2003	Nierlich et al.
D471,825	S	3/2003	Peabody
6,574,581	B1	6/2003	Bohrer et al.
6,595,430	B1	7/2003	Shah
6,619,055	B1	9/2003	Addy
6,622,925	B2	9/2003	Carner et al.
D480,401	S	10/2003	Kahn et al.
6,636,197	B1	10/2003	Goldenberg et al.
6,641,054	B2	11/2003	Morey
6,641,055	B1	11/2003	Tiernan
6,643,567	B2	11/2003	Kolk et al.
6,644,557	B1	11/2003	Jacobs
6,645,066	B2	11/2003	Gutta et al.
D485,279	S	1/2004	DeCombe
6,726,112	B1	4/2004	Ho
D491,956	S	6/2004	Ombao et al.
6,769,482	B2	8/2004	Wagner et al.
6,785,630	B2	8/2004	Kolk et al.
6,798,341	B1	9/2004	Eckel et al.
D497,617	S	10/2004	Decombe et al.
6,814,299	B1	11/2004	Carey
6,824,069	B2	11/2004	Rosen
6,851,621	B1	2/2005	Wacker et al.
6,864,879	B2	3/2005	Nojima et al.
D503,631	S	4/2005	Peabody
6,891,838	B1	5/2005	Petite et al.
6,909,921	B1	6/2005	Bilger
6,951,306	B2	10/2005	DeLuca
D511,527	S	11/2005	Hernandez et al.
6,975,958	B2	12/2005	Bohrer et al.
6,990,821	B2	1/2006	Singh et al.
7,000,849	B2	2/2006	Ashworth et al.
7,024,336	B2	4/2006	Salsbury et al.
7,028,912	B1	4/2006	Rosen
7,035,805	B1	4/2006	Miller
7,038,667	B1	5/2006	Vassallo et al.
7,055,759	B2	6/2006	Wacker et al.
7,083,109	B2	8/2006	Pouchak
7,108,194	B1	9/2006	Hankins, II
7,109,970	B1	9/2006	Miller
7,111,788	B2	9/2006	Reponen
7,114,554	B2	10/2006	Bergman et al.
7,135,965	B2	11/2006	Chapman, Jr. et al.
7,140,551	B2	11/2006	de Pauw et al.
7,141,748	B2	11/2006	Tanaka et al.
7,142,948	B2	11/2006	Metz
7,149,729	B2	12/2006	Kaasten et al.
7,152,806	B1	12/2006	Rosen
7,156,318	B1	1/2007	Rosen
7,159,789	B2	1/2007	Schwendinger et al.
7,159,790	B2	1/2007	Schwendinger et al.
7,181,317	B2	2/2007	Amundson et al.
7,188,482	B2	3/2007	Sadegh et al.
7,222,494	B2	5/2007	Peterson et al.
7,222,800	B2	5/2007	Wruck
7,225,054	B2	5/2007	Amundson et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

D544,877 S 6/2007 Sasser
7,258,280 B2 8/2007 Wolfson
D550,691 S 9/2007 Hally et al.
7,264,175 B2 9/2007 Schwendinger et al.
7,274,972 B2 9/2007 Amundson et al.
7,287,709 B2 10/2007 Proffitt et al.
7,289,887 B2 10/2007 Rodgers
7,299,996 B2 11/2007 Garrett et al.
7,302,642 B2 11/2007 Smith et al.
7,333,880 B2 2/2008 Brewster et al.
7,346,467 B2 3/2008 Bohrer et al.
D566,587 S 4/2008 Rosen
7,379,791 B2 5/2008 Tamarkin et al.
RE40,437 E 7/2008 Rosen
7,418,663 B2 8/2008 Pettinati et al.
7,427,926 B2 9/2008 Sinclair et al.
7,434,742 B2 10/2008 Mueller et al.
7,451,937 B2 11/2008 Flood et al.
7,455,240 B2 11/2008 Chapman, Jr. et al.
7,460,690 B2 12/2008 Cohen et al.
7,469,550 B2 12/2008 Chapman, Jr. et al.
D588,152 S 3/2009 Okada
7,509,753 B2 3/2009 Nicosia et al.
D589,792 S 4/2009 Clabough et al.
D590,412 S 4/2009 Saft et al.
D593,120 S 5/2009 Bouchard et al.
7,537,171 B2 5/2009 Mueller et al.
D594,015 S 6/2009 Singh et al.
D595,309 S 6/2009 Sasaki et al.
7,555,364 B2 6/2009 Poth et al.
D596,194 S 7/2009 Vu et al.
D597,101 S 7/2009 Chaudhri et al.
7,558,648 B2 7/2009 Hoglund et al.
D598,463 S 8/2009 Hirsch et al.
7,571,014 B1 8/2009 Lambourne et al.
7,571,865 B2 8/2009 Nicodem et al.
7,575,179 B2 8/2009 Morrow et al.
D599,810 S 9/2009 Scalisi et al.
7,584,899 B2 9/2009 de Pauw et al.
7,600,694 B2 10/2009 Helt et al.
D603,277 S 11/2009 Clausen et al.
D603,421 S 11/2009 Ebeling et al.
D604,740 S 11/2009 Matheny et al.
7,614,567 B2 11/2009 Chapman et al.
7,620,996 B2 11/2009 Torres et al.
D607,001 S 12/2009 Ording
7,624,931 B2 12/2009 Chapman, Jr. et al.
7,634,504 B2 12/2009 Amundson
7,641,126 B2 1/2010 Schultz et al.
7,644,869 B2 1/2010 Hoglund et al.
7,667,163 B2 2/2010 Ashworth et al.
D613,301 S 4/2010 Lee et al.
D614,194 S 4/2010 Guntaur et al.
D614,196 S 4/2010 Guntaur et al.
7,693,582 B2 4/2010 Bergman et al.
7,702,424 B2 4/2010 Cannon et al.
7,703,694 B2 4/2010 Mueller et al.
D614,976 S 5/2010 Skafdrup et al.
D615,546 S 5/2010 Lundy et al.
D616,460 S 5/2010 Pearson et al.
7,721,209 B2 5/2010 Tilton
7,726,581 B2 6/2010 Naujok et al.
D619,613 S 7/2010 Dunn
7,784,704 B2 8/2010 Harter
7,802,618 B2 9/2010 Simon et al.
D625,325 S 10/2010 Vu et al.
D625,734 S 10/2010 Kurozumi et al.
D626,133 S 10/2010 Murphy et al.
7,823,076 B2 10/2010 Borovsky et al.
RE41,922 E 11/2010 Gough et al.
7,845,576 B2 12/2010 Siddaramanna et al.
7,848,900 B2 12/2010 Steinberg et al.
7,854,389 B2 12/2010 Ahmed
D630,649 S 1/2011 Tokunaga et al.
7,890,195 B2 2/2011 Bergman et al.
7,900,849 B2 3/2011 Barton et al.
7,904,209 B2 3/2011 Podgorny et al.
7,904,830 B2 3/2011 Hoglund et al.
7,908,116 B2 3/2011 Steinberg et al.
7,908,117 B2 3/2011 Steinberg et al.
7,913,925 B2 3/2011 Ashworth
D638,835 S 5/2011 Akana et al.
D640,269 S 6/2011 Chen
D640,273 S 6/2011 Arnold et al.
D640,278 S 6/2011 Woo
D640,285 S 6/2011 Woo
D641,373 S 7/2011 Gardner et al.
7,984,384 B2 7/2011 Chaudhri et al.
D643,045 S 8/2011 Woo
8,010,237 B2 8/2011 Cheung et al.
8,019,567 B2 9/2011 Steinberg et al.
8,037,022 B2 10/2011 Rahman et al.
D648,735 S 11/2011 Arnold et al.
D651,529 S 1/2012 Mongell et al.
8,090,477 B1 1/2012 Steinberg
8,091,375 B2 1/2012 Crawford
8,091,794 B2 1/2012 Siddaramanna et al.
8,131,207 B2 3/2012 Hwang et al.
8,131,497 B2 3/2012 Steinberg et al.
8,131,506 B2 3/2012 Steinberg et al.
8,136,052 B2 3/2012 Shin et al.
D656,950 S 4/2012 Shallcross et al.
D656,952 S 4/2012 Weir et al.
8,156,060 B2 4/2012 Borzestowski et al.
8,166,395 B2 4/2012 Omi et al.
D658,674 S 5/2012 Shallcross et al.
8,180,492 B2 5/2012 Steinberg
8,185,164 B2 5/2012 Kim
8,195,313 B1 6/2012 Fadell et al.
D663,743 S 7/2012 Tanghe et al.
D663,744 S 7/2012 Tanghe et al.
D664,559 S 7/2012 Ismail et al.
8,219,249 B2 7/2012 Harrod et al.
8,223,134 B1 7/2012 Forstall et al.
8,234,581 B2 7/2012 Kake
D664,978 S 8/2012 Tanghe et al.
D665,397 S 8/2012 Naranjo et al.
8,243,017 B2 8/2012 Brodersen et al.
8,253,704 B2 8/2012 Jang
8,253,747 B2 8/2012 Niles et al.
8,280,536 B1 10/2012 Fadell et al.
8,281,244 B2 10/2012 Neuman et al.
D671,136 S 11/2012 Barnett et al.
8,316,022 B2 11/2012 Matsuda et al.
D673,171 S 12/2012 Peters et al.
D673,172 S 12/2012 Peters et al.
8,341,557 B2 12/2012 Pisula et al.
8,442,695 B2 5/2013 Imes et al.
2001/0052052 A1 12/2001 Peng
2002/0005435 A1 1/2002 Cottrell
2002/0022991 A1 2/2002 Sharood et al.
2003/0034898 A1 2/2003 Shamoon et al.
2003/0042320 A1 3/2003 Decker
2003/0112262 A1 6/2003 Adatia et al.
2003/0231001 A1 12/2003 Bruning
2004/0015504 A1 1/2004 Ahad et al.
2004/0034484 A1 2/2004 Solomita, Jr. et al.
2004/0055446 A1 3/2004 Robbin et al.
2004/0067731 A1* 4/2004 Brinkerhoff et al. 454/325
2004/0074978 A1 4/2004 Rosen
2004/0095237 A1 5/2004 Chen et al.
2004/0164238 A1 8/2004 Xu et al.
2004/0249479 A1 12/2004 Shorrock
2004/0256472 A1 12/2004 DeLuca
2004/0260427 A1 12/2004 Wimsatt
2004/0262410 A1 12/2004 Hull
2005/0040250 A1* 2/2005 Wruck 236/51
2005/0043907 A1 2/2005 Eckel et al.
2005/0055432 A1 3/2005 Rodgers
2005/0071780 A1 3/2005 Muller et al.
2005/0090915 A1 4/2005 Geiwitz
2005/0103875 A1 5/2005 Ashworth et al.
2005/0119766 A1 6/2005 Amundson et al.
2005/0119793 A1 6/2005 Amundson et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0120181 A1 6/2005 Arunagirinathan et al.
2005/0128067 A1 6/2005 Zakrewski
2005/0150968 A1 7/2005 Shearer
2005/0159847 A1 7/2005 Shah et al.
2005/0189429 A1 9/2005 Breeden
2005/0192915 A1 9/2005 Ahmed et al.
2005/0194456 A1 9/2005 Tessier et al.
2005/0199737 A1 9/2005 De Pauw et al.
2005/0204997 A1 9/2005 Fournier
2005/0279840 A1 12/2005 Schwendinger et al.
2005/0279841 A1 12/2005 Schwendinger et al.
2005/0280421 A1 12/2005 Yomoda et al.
2006/0000919 A1 1/2006 Schwendinger et al.
2006/0186214 A1 8/2006 Simon et al.
2006/0196953 A1 9/2006 Simon et al.
2007/0001830 A1 1/2007 Dagci et al.
2007/0045430 A1 3/2007 Chapman et al.
2007/0045433 A1 3/2007 Chapman et al.
2007/0045444 A1 3/2007 Gray et al.
2007/0050732 A1 3/2007 Chapman et al.
2007/0057079 A1 3/2007 Stark et al.
2007/0114295 A1 5/2007 Jenkins
2007/0115902 A1 5/2007 Shamoon et al.
2007/0132503 A1 6/2007 Nordin
2007/0157639 A1 7/2007 Harrod
2007/0158442 A1 7/2007 Chapman et al.
2007/0158444 A1 7/2007 Naujok et al.
2007/0173978 A1 7/2007 Fein et al.
2007/0220907 A1* 9/2007 Ehlers 62/126
2007/0221741 A1 9/2007 Wagner et al.
2007/0225867 A1 9/2007 Moorer et al.
2007/0227721 A1 10/2007 Springer et al.
2007/0228183 A1 10/2007 Kennedy et al.
2007/0241203 A1 10/2007 Wagner et al.
2007/0246553 A1* 10/2007 Morrow et al. ..... 236/46 R
2007/0257120 A1 11/2007 Chapman et al.
2007/0278320 A1 12/2007 Lunacek et al.
2007/0296280 A1 12/2007 Sorg et al.
2008/0006709 A1 1/2008 Ashworth et al.
2008/0015740 A1 1/2008 Osann
2008/0015742 A1 1/2008 Kulyk et al.
2008/0048046 A1 2/2008 Wagner et al.
2008/0054082 A1 3/2008 Evans et al.
2008/0099568 A1 5/2008 Nicodem et al.
2008/0155915 A1* 7/2008 Howe et al. 52/220.3
2008/0191045 A1 8/2008 Harter
2008/0215240 A1* 9/2008 Howard et al. 701/213
2008/0221737 A1 9/2008 Josephson et al.
2008/0245480 A1 10/2008 Knight et al.
2008/0273754 A1 11/2008 Hick et al.
2008/0290183 A1 11/2008 Laberge et al.
2008/0317292 A1 12/2008 Baker et al.
2009/0001180 A1 1/2009 Siddaramanna et al.
2009/0001181 A1 1/2009 Siddaramanna et al.
2009/0099699 A1 4/2009 Steinberg et al.
2009/0125151 A1 5/2009 Steinberg et al.
2009/0140056 A1 6/2009 Leen
2009/0140057 A1 6/2009 Leen
2009/0140060 A1 6/2009 Stoner et al.
2009/0140062 A1 6/2009 Amundson et al.
2009/0140064 A1 6/2009 Schultz et al.
2009/0143916 A1 6/2009 Boll et al.
2009/0143918 A1 6/2009 Amundson et al.
2009/0171862 A1 7/2009 Harrod et al.
2009/0194601 A1 8/2009 Flohr
2009/0254225 A1 10/2009 Boucher et al.
2009/0259713 A1 10/2009 Blumrich et al.
2009/0261174 A1 10/2009 Butler et al.
2009/0263773 A1 10/2009 Kotlyar et al.
2009/0273610 A1 11/2009 Busch et al.
2009/0283603 A1 11/2009 Peterson et al.
2009/0297901 A1 12/2009 Kilian et al.
2009/0327354 A1 12/2009 Resnick et al.
2010/0019051 A1 1/2010 Rosen
2010/0025483 A1 2/2010 Hoeynck et al.
2010/0050004 A1 2/2010 Hamilton, II et al.
2010/0053464 A1 3/2010 Otsuka
2010/0070084 A1 3/2010 Steinberg et al.
2010/0070085 A1 3/2010 Harrod et al.
2010/0070086 A1 3/2010 Harrod et al.
2010/0070089 A1 3/2010 Harrod et al.
2010/0070093 A1 3/2010 Harrod et al.
2010/0070234 A1 3/2010 Steinberg et al.
2010/0070907 A1 3/2010 Harrod et al.
2010/0076605 A1 3/2010 Harrod et al.
2010/0076835 A1 3/2010 Silverman
2010/0084482 A1 4/2010 Kennedy et al.
2010/0106305 A1 4/2010 Pavlak et al.
2010/0107070 A1 4/2010 Devineni et al.
2010/0107076 A1 4/2010 Grohman et al.
2010/0107103 A1 4/2010 Wallaert et al.
2010/0163633 A1 7/2010 Barrett et al.
2010/0167783 A1 7/2010 Alameh et al.
2010/0168924 A1 7/2010 Tessier et al.
2010/0179704 A1 7/2010 Ozog
2010/0198425 A1 8/2010 Donovan
2010/0211224 A1 8/2010 Keeling et al.
2010/0262298 A1 10/2010 Johnson et al.
2010/0262299 A1 10/2010 Cheung et al.
2010/0280667 A1 11/2010 Steinberg
2010/0282857 A1 11/2010 Steinberg
2010/0289643 A1 11/2010 Trundle et al.
2010/0308119 A1 12/2010 Steinberg et al.
2010/0318227 A1 12/2010 Steinberg et al.
2011/0001812 A1 1/2011 Kang et al.
2011/0015797 A1 1/2011 Gilstrap
2011/0015798 A1 1/2011 Golden et al.
2011/0015802 A1 1/2011 Imes
2011/0016017 A1 1/2011 Carlin et al.
2011/0022242 A1 1/2011 Bukhin et al.
2011/0046756 A1 2/2011 Park
2011/0046792 A1 2/2011 Imes et al.
2011/0046805 A1 2/2011 Bedros et al.
2011/0046806 A1 2/2011 Nagel et al.
2011/0054710 A1 3/2011 Imes et al.
2011/0077758 A1 3/2011 Tran et al.
2011/0077896 A1 3/2011 Steinberg et al.
2011/0082594 A1* 4/2011 Dage et al. 700/278
2011/0106328 A1 5/2011 Zhou et al.
2011/0151837 A1 6/2011 Winbush, III
2011/0160913 A1* 6/2011 Parker et al. 700/276
2011/0166828 A1 7/2011 Steinberg et al.
2011/0167369 A1 7/2011 van Os
2011/0185895 A1 8/2011 Freen
2011/0290893 A1 12/2011 Steinberg
2011/0307103 A1 12/2011 Cheung et al.
2011/0307112 A1 12/2011 Barrilleaux
2012/0017611 A1 1/2012 Coffel et al.
2012/0036250 A1 2/2012 Vaswani et al.
2012/0053745 A1 3/2012 Ng
2012/0065935 A1 3/2012 Steinberg et al.
2012/0085831 A1 4/2012 Kopp
2012/0086562 A1 4/2012 Steinberg
2012/0089523 A1 4/2012 Hurri et al.
2012/0130546 A1 5/2012 Matas et al.
2012/0130547 A1 5/2012 Fadell et al.
2012/0131504 A1 5/2012 Fadell et al.
2012/0158350 A1 6/2012 Steinberg et al.
2012/0179300 A1 7/2012 Warren et al.
2012/0203379 A1 8/2012 Sloo et al.
2012/0221151 A1 8/2012 Steinberg
2012/0239207 A1 9/2012 Fadell et al.
2013/0024799 A1 1/2013 Fadell et al.
2013/0090767 A1 4/2013 Bruck et al.
2013/0099011 A1 4/2013 Matsuoka et al.

FOREIGN PATENT DOCUMENTS

EP 207295 1/1987
EP 434926 A2 7/1991
EP 196069 12/1991
EP 720077 A2 7/1996
EP 802471 A2 10/1997
EP 802471 8/1999

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	1065079	A2	1/2001
EP	1731984	A1	12/2006
EP	1283396		3/2007
EP	2157492	A2	2/2010
EP	1703356		9/2011
GB	2212317	B	5/1992
JP	59106311	A	6/1984
JP	01252850		10/1989
JP	09298780		11/1997
JP	10023565		1/1998
JP	2002087050	A	3/2002
JP	2003054290	A	2/2003
KR	1020070117874		3/2007
NL	1024986	C2	6/2005
WO	0248851	A2	6/2002
WO	2005019740		3/2005
WO	2008054938		5/2008
WO	2009073496	A2	6/2009
WO	2010033563		3/2010
WO	2011128416	A2	10/2011
WO	2011149600		12/2011
WO	2012024534		2/2012
WO	2013059671		4/2013

OTHER PUBLICATIONS

Honeywell CT2700, An Electronic Round Programmable Thermostat—User's Guide, Honeywell, Inc., 1997, 8 pages.

Honeywell CT8775A,C, The digital Round Non-Programmable Thermostats—Owner's Guide, Honeywell International Inc., 2003, 20 pages.

Honeywell T8700C, An Electronic Round Programmable Thermostat—Owner's Guide, Honeywell, Inc., 1997, 12 pages.

Honeywell T8775 The Digital Round Thermostat, Honeywell, 2003, 2 pages.

Honeywell T8775AC Digital Round Thermostat Manual No. 69-1679EF-1, www.honeywell.com/yourhome, Jun. 2004, pp. 1-16.

ICY 3815TT-001 Timer-Thermostat Package Box, ICY BV Product Bar Code No. 8717953007902, 2009, 2 pages.

Introducing the New Smart Si Thermostat, Datasheet [online]. Ecobee, No Date Given [retrieved on Feb. 25, 2013]. Retrieved from the Internet: <URL: https://www.ecobee.com/solutions/home/smart-si/>.

The Clever Thermostat, ICY BV Web Page, http://www.icy.nl/en/consumer/products/clever-thermostat, ICY BV, 2012, 1 page.

The Clever Thermostat User Manual and Installation Guide, ICY BV ICY3815 Timer-Thermostat, 2009, pp. 1-36.

U.S. Provisional U.S. Appl. No. 60/512,886, Volkswagen Rotary Knob for Motor Vehicle—English Translation of German Application filed Oct. 20, 2003.

Arens et al., "Demand Response Electrical Appliance Manager—User Interface Design, Development and Testing", Poster, Demand Response Enabling Technology Development, University of California Berkeley, Retrieved from dr.berkeley.edu/dream/posters/2005_6GUIposter.pdf, 2005, 1 page.

Arens et al., "Demand Response Enabled Thermostat—Control Strategies and Interface", Demand Response Enabling Technology Development Poster, University of California Berkeley, Retrieved from dr.berkeley.edu/dream/posters/2004_110EC_TstatPoster.pdf, 2004, 1 page.

Arens et al., "Demand Response Enabling Technology Development", Phase I Report: Jun. 2003-Nov. 2005, Jul. 27, P:/DemandRes/Uc Papers/DR-Phase1Report-Final DraftApril24-26.doc, University of California Berkeley, pp. 1-108.

Arens et al., "New Thermostat Demand Response Enabling Technology", Poster, University of California Berkeley, Jun. 10, 2004.

Auslander et al., "UC Berkeley DR Research Energy Management Group", Power Point Presentation, DR ETD Workshop, State of California Energy Commission, Jun. 11, 2007, pp. 1-35.

Chen et al., "Demand Response-Enabled Residential Thermostat Controls", Abstract, ACEEE Summer Study on Energy Efficiency in Buildings, Mechanical Engineering Dept. and Architecture Dept., University of California Berkeley, 2008, pp. 1-24 through 1-36.

Green, "Thermo Heat Tech Cool", Popular Mechanics Electronic Thermostat Guide, Oct. 1985, pp. 155-158.

Meier et al., "Thermostat Interface Usability: A Survey", Ernest Orlando Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, Berkeley California., Sep. 2010, pp. 1-73.

Peffer et al., "A Tale of Two Houses: The Human Dimension of Demand Response Enabling Technology from a Case Study of Adaptive Wireless Thermostat", Abstract, ACEEE Summer Study on Energy Efficiency in Buildings, Architecture Dept. and Mechanical Engineering Dept., University of California Berkeley., 2008, pp. 7-242 through 7-253.

Peffer et al., "Smart Comfort At Home: Design of a Residential Thermostat to Achieve Thermal Comfort, and Save Money and Peak Energy", University of California Berkeley, Mar. 2007, 1 page.

Salus, "S-Series Digital Thermostat Instruction Manual-ST620 Model No. Instruction Manual", www.salus-tech.com, Version 005, Apr. 29, 2010, 24 pages.

Sanford, "iPod (Click Wheel) (2004)", www.apple-history.com [retrieved on Apr. 9, 2012]. Retrieved from: http://apple-history.com/ipod, Apr. 9, 2012, 2 pages.

Wright et al., "DR ETD—Summary of New Thermostat, TempNode, & New Meter (UC Berkeley Project)", Power Point Presentation, Public Interest Energy Research, University of California Berkeley. Retrieved from: http://dr.berkeley.edu/dream/presentations/2005_6CEC.pdf, 2005, pp. 1-49.

Advanced Model Owner's Manual, Bay Web Thermostat, manual [online], [retrieved on Nov. 7, 2012]. Retrieved from the Internet: <URL:http://www.bayweb.com/wp-content/uploads/BW-WT4-2DOC.pdf>, Oct. 6, 2011, 31 pages.

Aprilaire Electronic Thermostats Model 8355 User's Manual, Research Products Corporation, Dec. 2000, 16 pages.

Braeburn 5300 Installer Guide, Braeburn Systems, LLC, Dec. 9, 2009, 10 pages.

Braeburn Model 5200, Braeburn Systems, LLC, Jul. 20, 2011, 11 pages.

Ecobee Smart Si Thermostat Installation Manual, Ecobee, Apr. 3, 2012, 40 pages.

Ecobee Smart Si Thermostat User Manual, Ecobee, Apr. 3, 2012, 44 pages.

Ecobee Smart Thermostat Installation Manual, Jun. 29, 2011, 20 pages.

Ecobee Smart Thermostat User Manual, May 11, 2010, 20 pages.

Electric Heat Lock Out on Heat Pumps, Washington State University Extension Energy Program, Apr. 2010, pp. 1-3.

Honeywell Installation Guide FocusPRO TH6000 Series, Honeywell International, Inc., Jan. 5, 2012, 24 pages.

Honeywell Operating Manual FocusPRO TH6000 Series, Honeywell International, Inc., Mar. 25, 2011, 80 pages.

Honeywell Prestige IAQ Product Data 2, Honeywell International, Inc., Jan. 12, 2012, 126 pages.

Honeywell Prestige THX9321 and TXH9421 Product Data, Honeywell International, Inc., 68-0311, Jan. 2012, 126 pages.

Honeywell Prestige THX9321-9421 Operating Manual, Honeywell International, Inc., Jul. 6, 2011, 120 pages.

Hunter Internet Thermostat Installation Guide, Hunter Fan Co., Aug. 14, 2012, 8 pages.

Lennox ComfortSense 5000 Owners Guide, Lennox Industries, Inc., Feb. 2008, 32 pages.

Lennox ComfortSense 7000 Owners Guide, Lennox Industries, Inc., May 2009, 15 pages.

Lennox iComfort Manual, Lennox Industries, Inc., Dec. 2010, 20 pages.

Lux PSPU732T Manual, LUX Products Corporation, Jan. 6, 2009, 48 pages.

NetX RP32-WIFI Network Thermostat Consumer Brochure, Network Thermostat, May 2011, 2 pages.

NetX RP32-WIFI Network Thermostat Specification Sheet, Network Thermostat, Feb. 28, 2012, 2 pages.

RobertShaw Product Manual 9620, Maple Chase Company, Jun. 12, 2001, 14 pages.

(56) **References Cited**

OTHER PUBLICATIONS

RobertShaw Product Manual 9825i2, Maple Chase Company, Jul. 17, 2006, 36 pages.
SCE Energy$mart Thermostat Study for Southern California Edison—Presentation of Study Results, Population Research Systems, Project #1010, Nov. 10, 2004, 51 pages.
SYSTXCCUIZ01-V Infinity Control Installation Instructions, Carrier Corp, May 31, 2012, 20 pages.
T8611G Chronotherm IV Deluxe Programmable Heat Pump Thermostat Product Data, Honeywell International Inc., Oct. 1997, 24 pages.
TB-PAC, TB-PHP, Base Series Programmable Thermostats, Carrier Corp, May 14, 2012, 8 pages.
The Perfect Climate Comfort Center PC8900A W8900A-C Product Data Sheet, Honeywell International Inc, Apr. 2001, 44 pages.
TP-PAC, TP-PHP, TP-NAC, TP-NHP Performance Series AC/HP Thermostat Installation Instructions, Carrier Corp, Sep. 2007, 56 pages.
Trane Communicating Thermostats for Fan Coil, Trane, May 2011, 32 pages.
Trane Communicating Thermostats for Heat Pump Control, Trane, May 2011, 32 pages.
Trane Install XL600 Installation Manual, Trane, Mar. 2006, 16 pages.
Trane XL950 Installation Guide, Trane, Mar. 2011, 20 pages.
Venstar T2900 Manual, Venstar, Inc., Apr. 2008, 113 pages.
Venstar T5800 Manual, Venstar, Inc., Sep. 7, 2011, 63 pages.
VisionPRO TH8000 Series Installation Guide, Honeywell International, Inc., Jan. 2012, 12 pages.
VisionPRO TH8000 Series Operating Manual, Honeywell International, Inc., Mar. 2011, 96 pages.
VisionPRO Wi-Fi Programmable Thermostat, Honeywell International, Inc. Operating Manual, Aug. 2012, 48 pages.
White Rodgers (Emerson) Model 1F81-261 Installation and Operating Instructions, White Rodgers, Apr. 15, 2010, 8 pages.
White Rodgers (Emerson) Model IF98EZ-1621 Homeowner's User Guide, White Rodgers, Jan. 25, 2012, 28 pages.
Allen, et al., "Real-Time Earthquake Detection and Hazard Assessment by ElarmS Across California", Geophysical Research Letters, vol. 36, L00B08, 2009, pp. 1-6.
Bourke, Server Load Balancing, O'Reilly & Associates, Inc., Aug. 2001, 182 pages.
De Almeida, et al., "Advanced Monitoring Technologies for the Evaluation of Demand-Side Management Programs", Energy, vol. 19, No. 6, 1994, pp. 661-678.
Deleeuw, "Ecobee WiFi Enabled Smart Thermostat Part 2: The Features Review", Retrieved from <URL: http://www.homenetworkenabled.com/content.php?136-ecobee-WiFi-enabled-Smart-Thermostat-Part-2-The-Features-review>, Dec. 2, 2011, 5 pages.
Gao, et al., "The Self-Programming Thermostat: Optimizing Setback Schedules Based on Home Occupancy Patterns", In Proceedings of the First ACM Workshop on Embedded Sensing Systems for Energy-Efficiency in Buildings, Nov. 3, 2009, 6 pages.
Gevorkian, "Alternative Energy Systems in Building Design", 2009, pp. 195-200.
Hoffman, et al., "Integration of Remote Meter Reading, Load Control and Monitoring of Customers' Installations for Customer Automation with Telephone Line Signaling", Electricity Distribution, 1989. CIRED 1989. 10th International Conference on, May 8-12, 1989, pp. 421-424.
Levy, "A Vision of Demand Response—2016", The Electricity Journal, vol. 19, Issue 8, Oct. 2006, pp. 12-23.
Loisos, et al., "Buildings End-Use Energy Efficiency: Alternatives to Compressor Cooling", California Energy Commission, Public Interest Energy Research, Jan. 2000, 80 pages.
Lopes, "Case Studies in Advanced Thermostat Control for Demand Response", AEIC Load Research Conference, St. Louis, MO, Jul. 2004, 36 pages.
Lu, et al., "The Smart Thermostat: Using Occupancy Sensors to Save Energy in Homes", In Proceedings of the 8th ACM Conference on Embedded Networked Sensor Systems, Nov. 3-5, 2010, pp. 211-224.
Martinez, "SCE Energy$mart Thermostat Program", Advanced Load Control Alliance, Oct. 5, 2004, 20 pages.
Matty, "Advanced Energy Management for Home Use", IEEE Transaction on Consumer Electronics, vol. 35, No. 3, Aug. 1989, pp. 584-588.
Motegi, et al., "Introduction to Commercial Building Control Strategies and Techniques for Demand Response", Demand Response Research Center, May 22, 2007, 35 pages.
Mozer, "The Neural Network House: An Environmental that Adapts to it's Inhabitants", AAAI Technical Report SS-98-02, 1998, pp. 110-114.
White, et al., "A Conceptual Model for Simulation Load Balancing", Proc. 1998 Spring Simulation Interoperability Workshop, 1998, 7 pages.

* cited by examiner

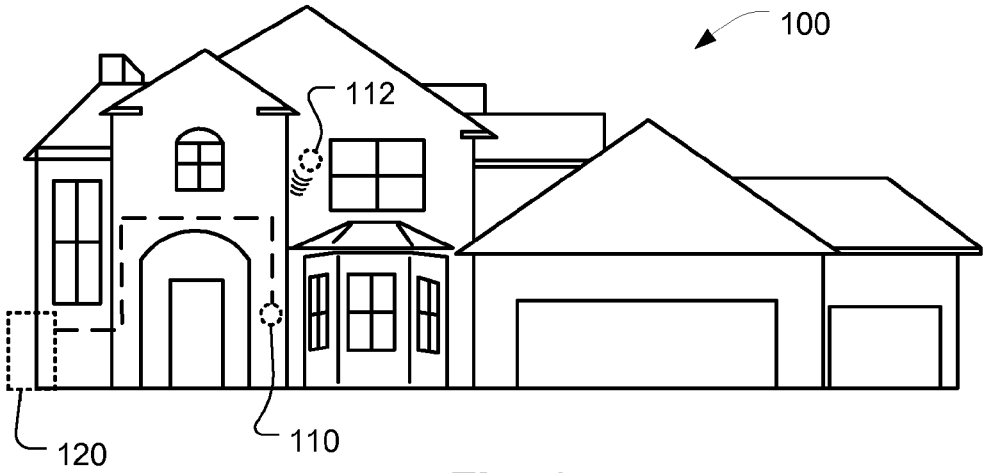

100
112
120
110

Fig. 1

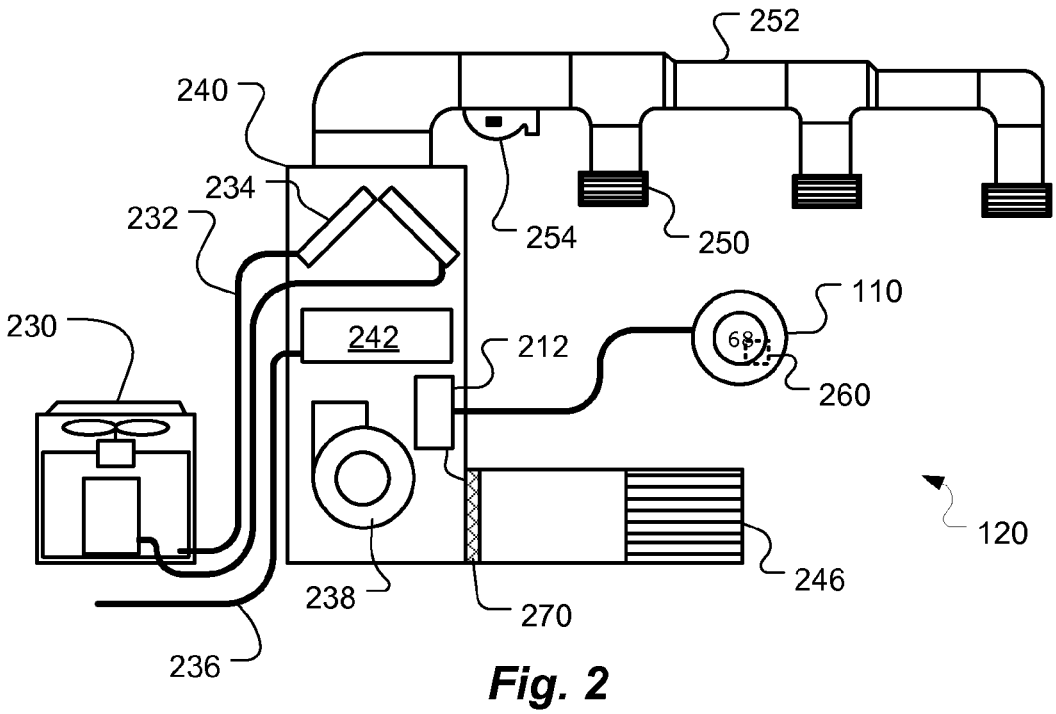

252
240
234
232
254
250
110
230
242
212
68
260
120
246
238
270
236

Fig. 2

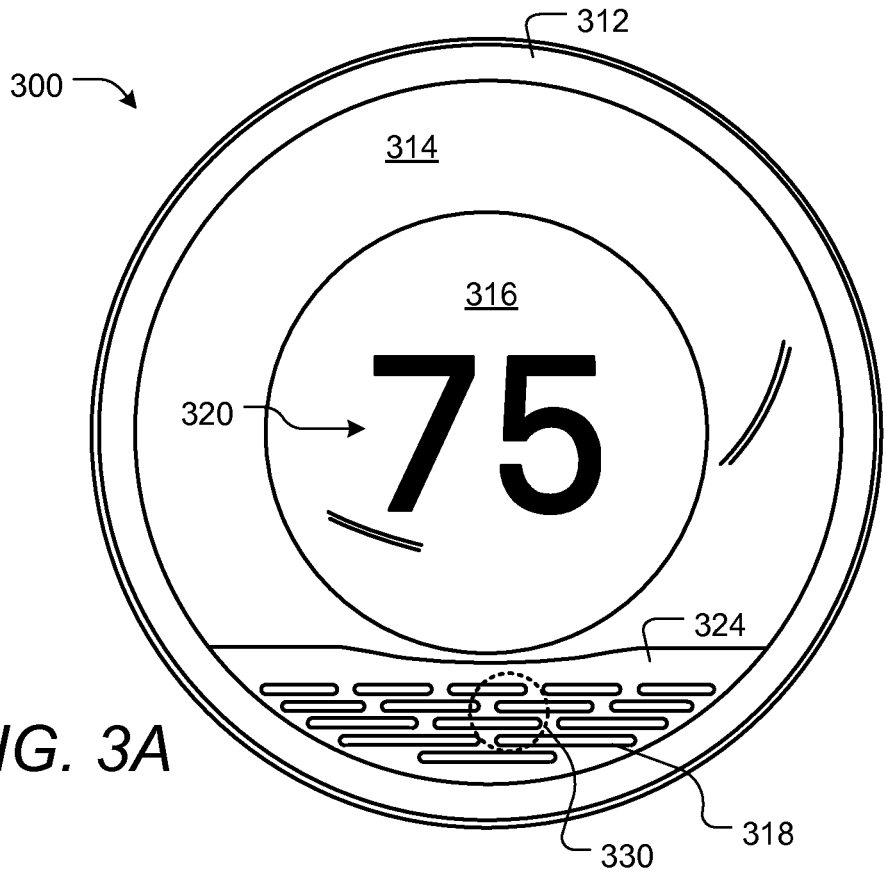

300
312
314
316
75
320
324
318
330

FIG. 3A

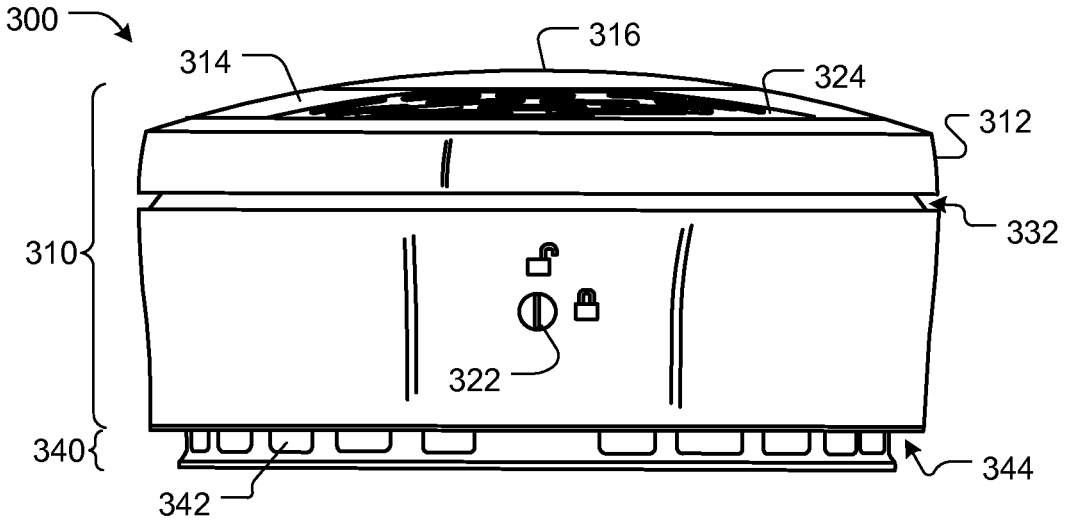

300
314
316
324
312
332
310
322
340
342
344

FIG. 3B

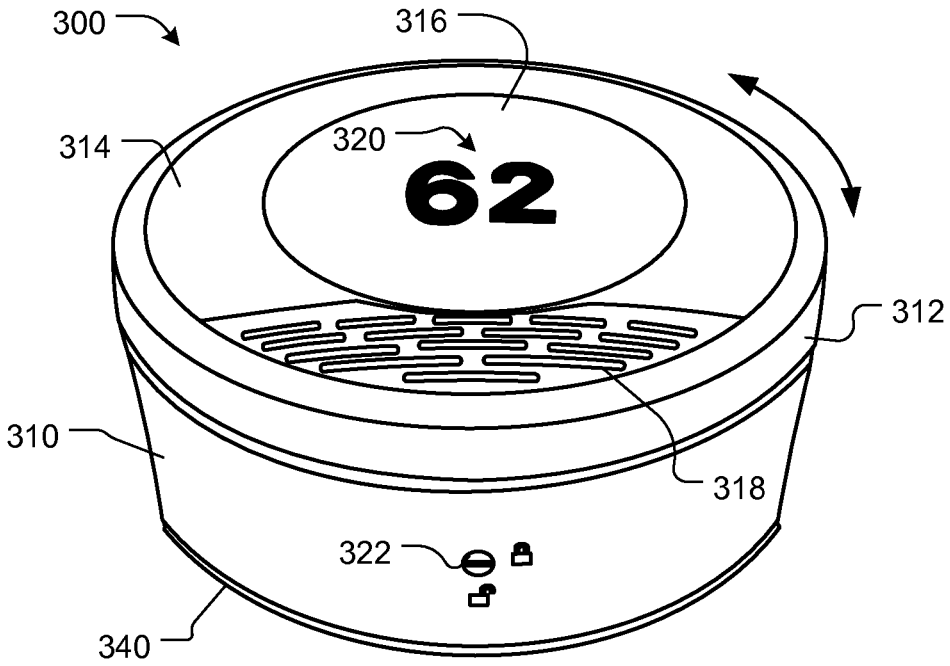


FIG. 3C

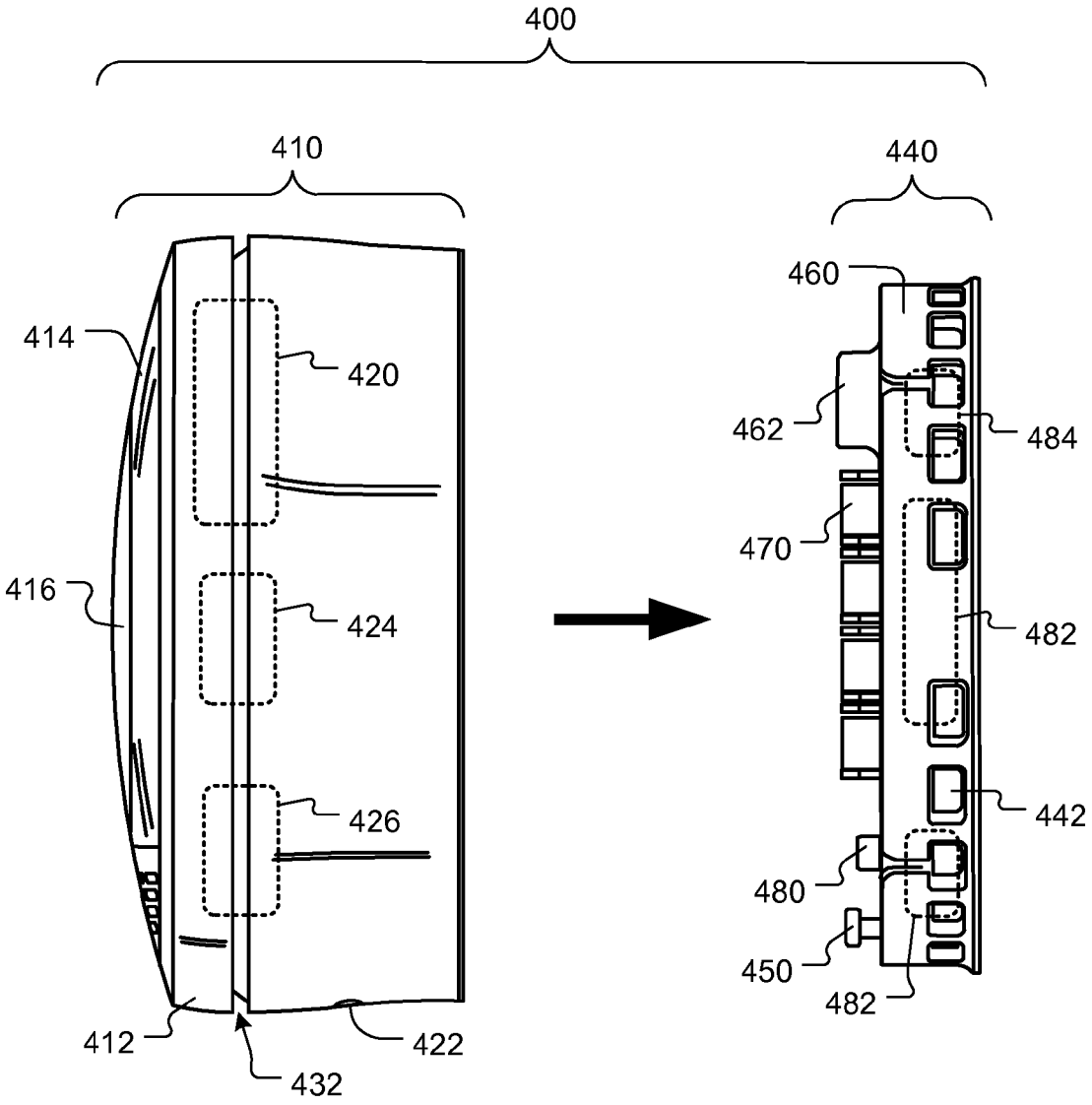

400
410
440
414
420
416
424
426
412
422
432
460
462
484
470
482
442
480
450
482

FIG. 4A

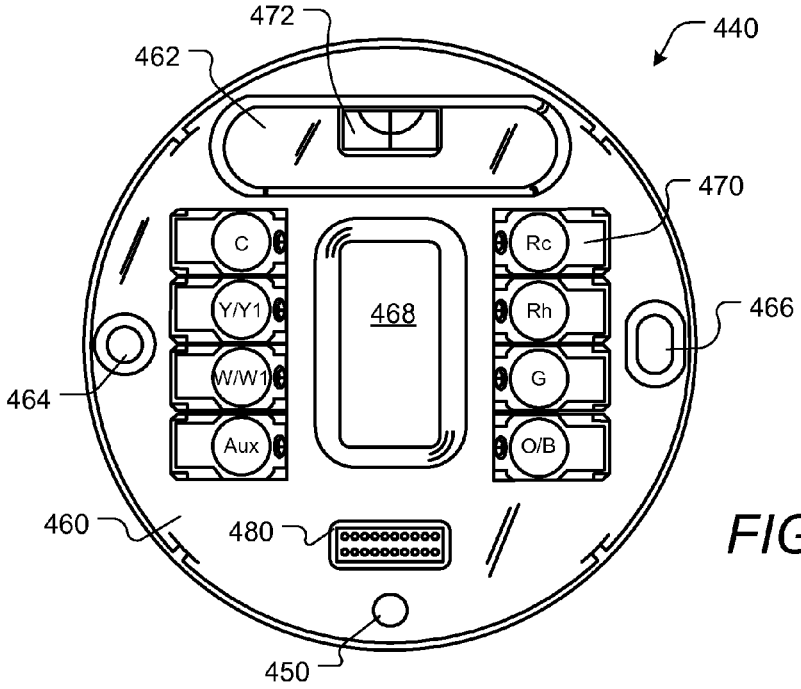

472
462
440
470
C
Y/Y1
W/W1
Aux
468
Rc
Rh
G
O/B
466
464
460
480
450

FIG. 4B

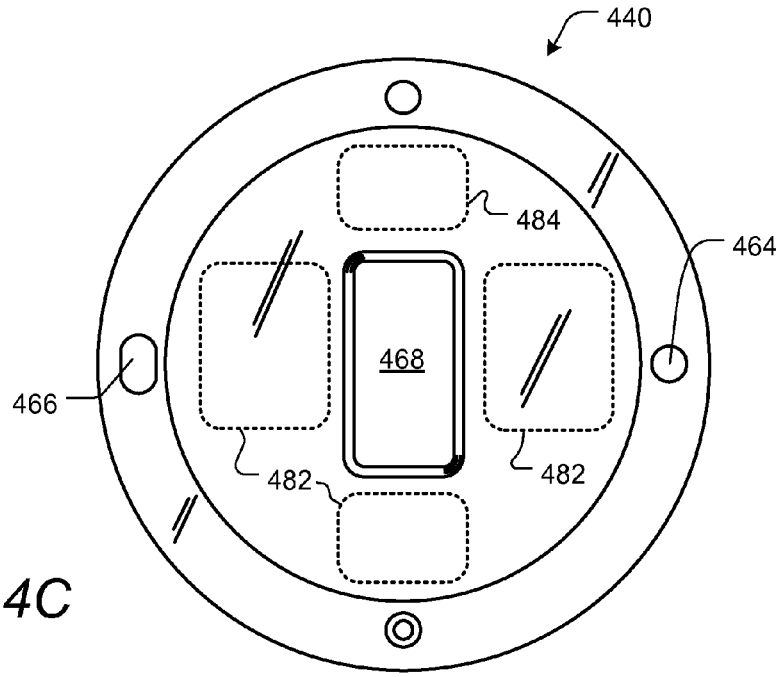

440
484
464
468
466
482
482

FIG. 4C

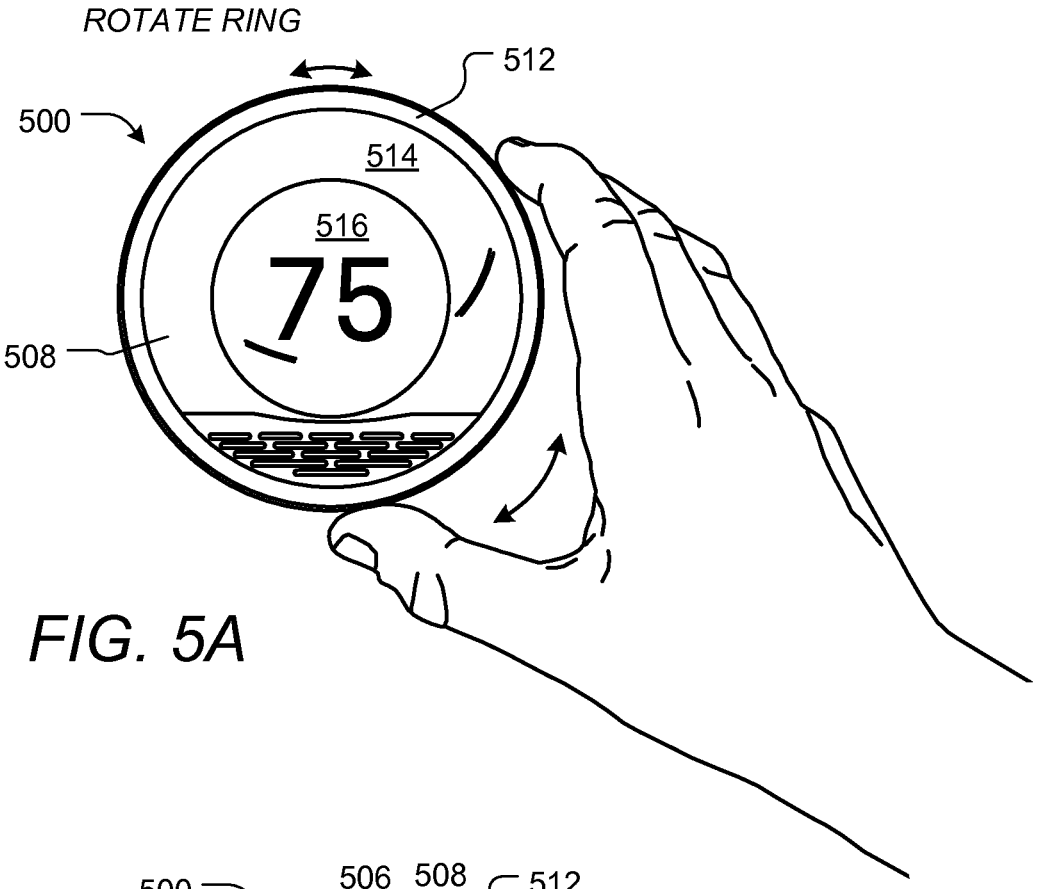

ROTATE RING
512
500
514
516
75
508

FIG. 5A

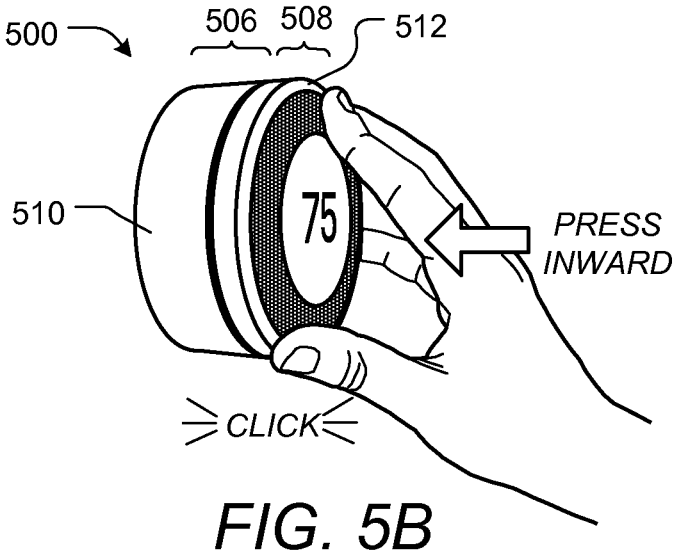

500
506
508
512
510
75
PRESS
INWARD
CLICK

FIG. 5B

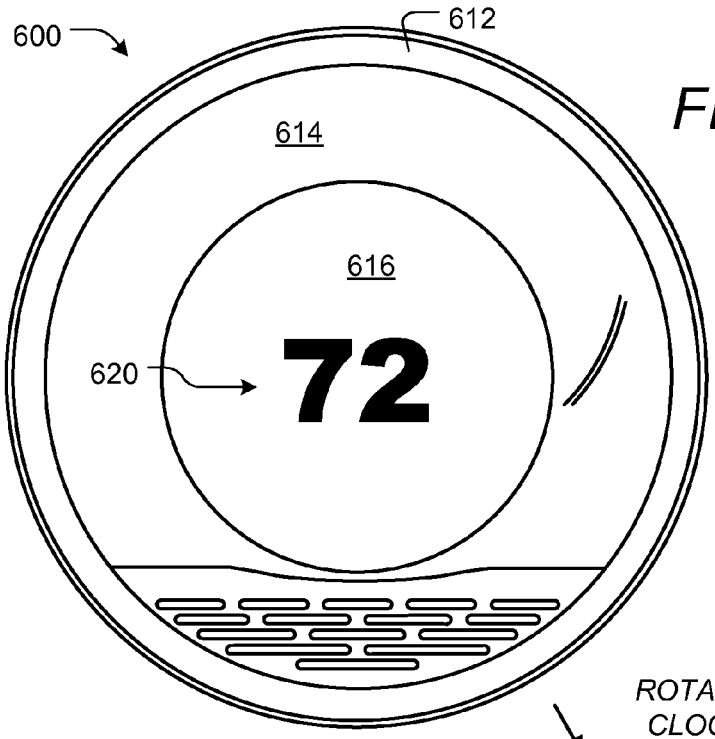


FIG. 6A

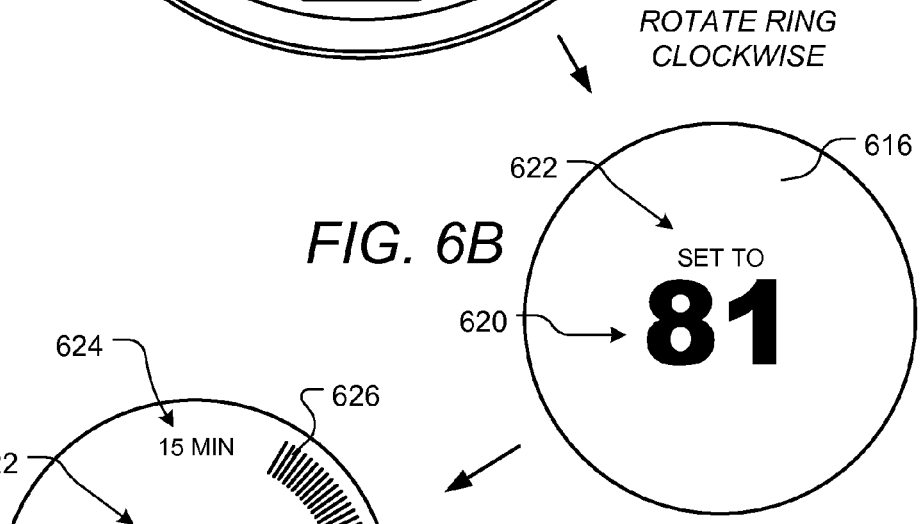


FIG. 6B

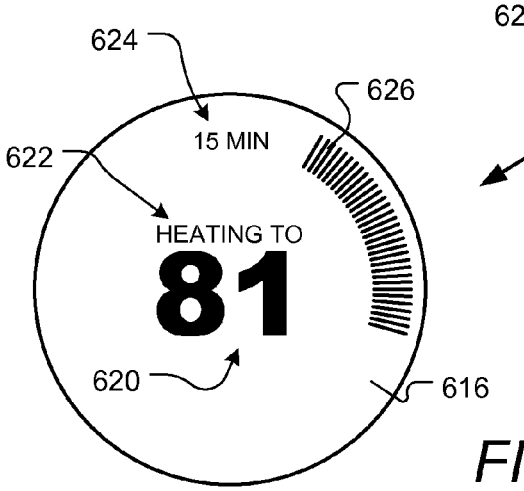


FIG. 6C

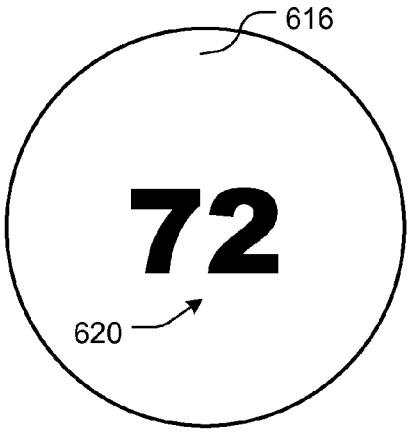


FIG. 6D

ROTATE RING
COUNTER-CLOCKWISE

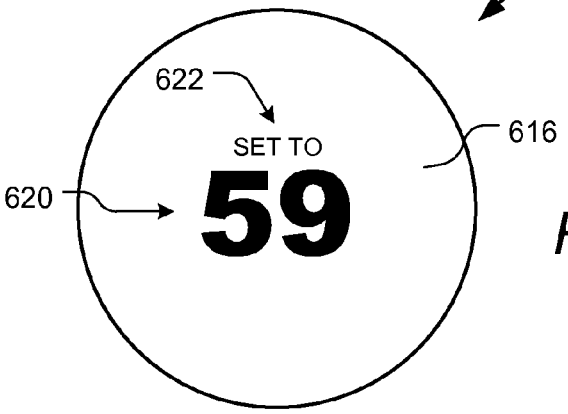


FIG. 6E

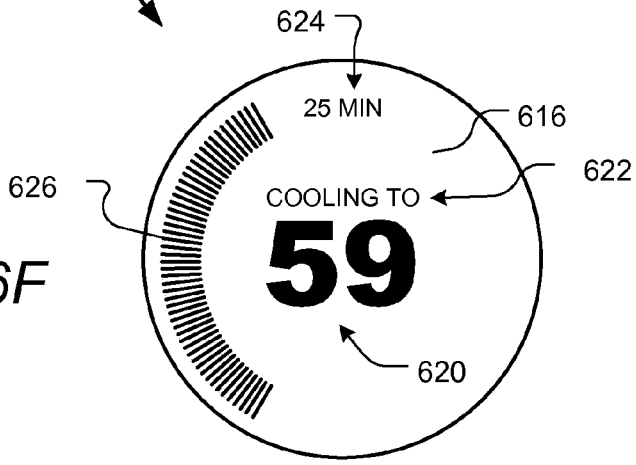


FIG. 6F

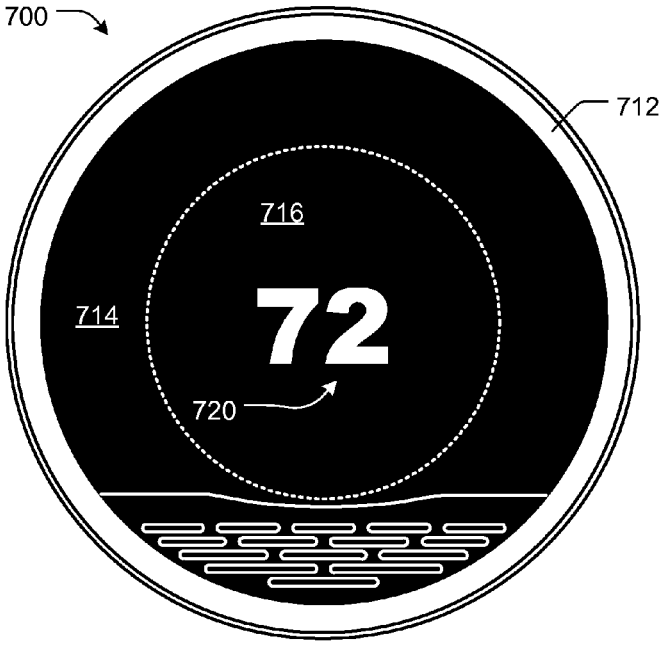


FIG. 7A

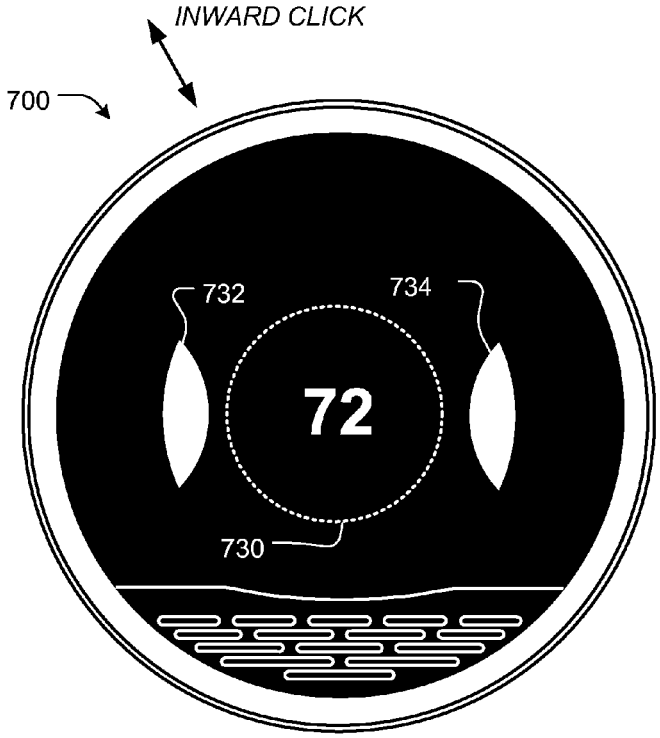


FIG. 7B

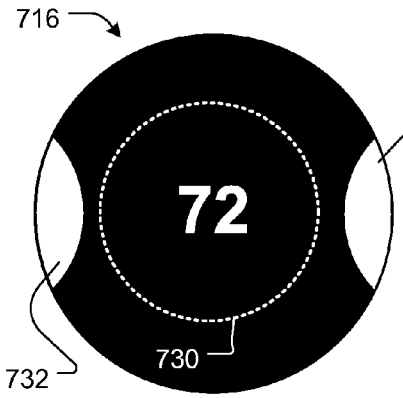


FIG. 7C

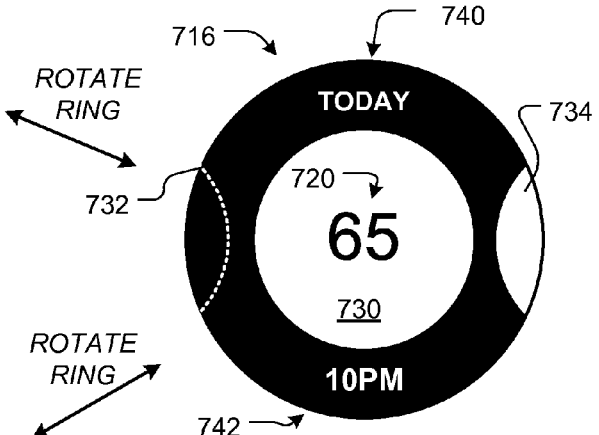


FIG. 7D

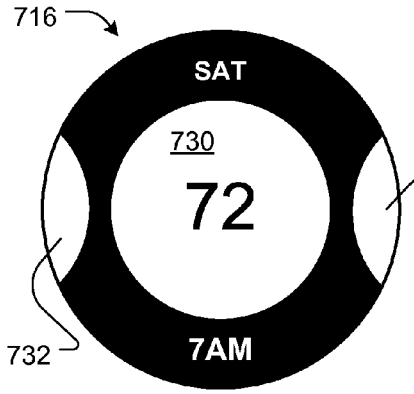


FIG. 7E

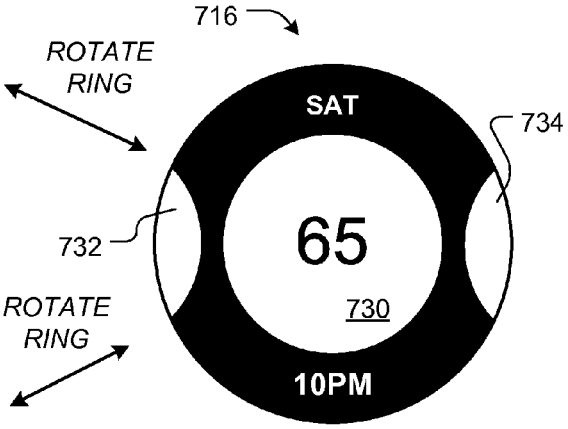


FIG. 7F

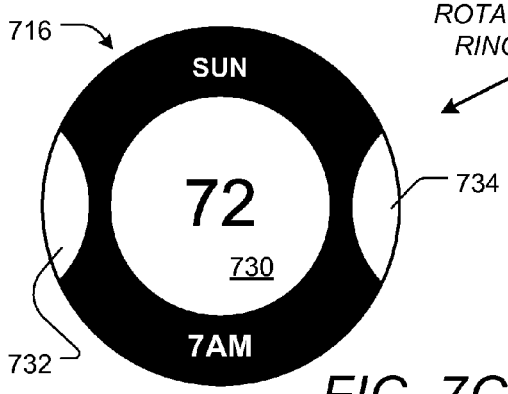


FIG. 7G

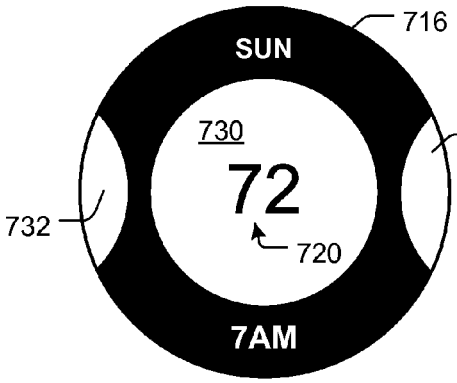


FIG. 7H

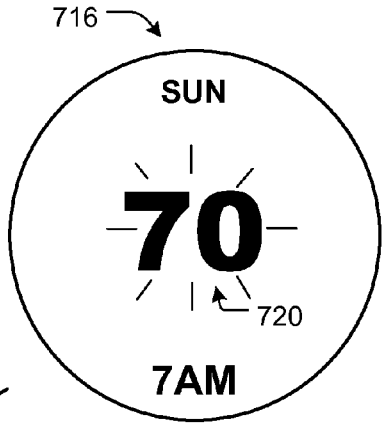


FIG. 7I

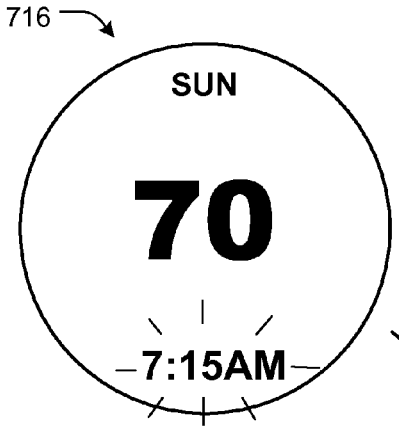


FIG. 7J

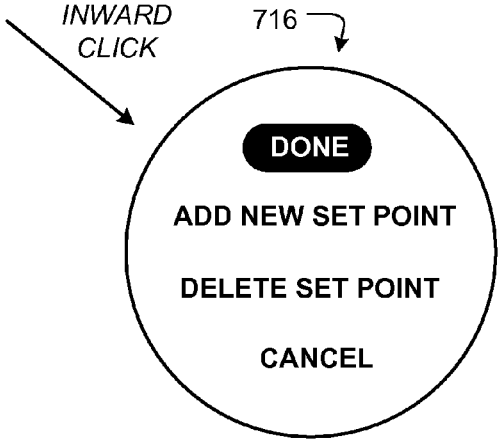
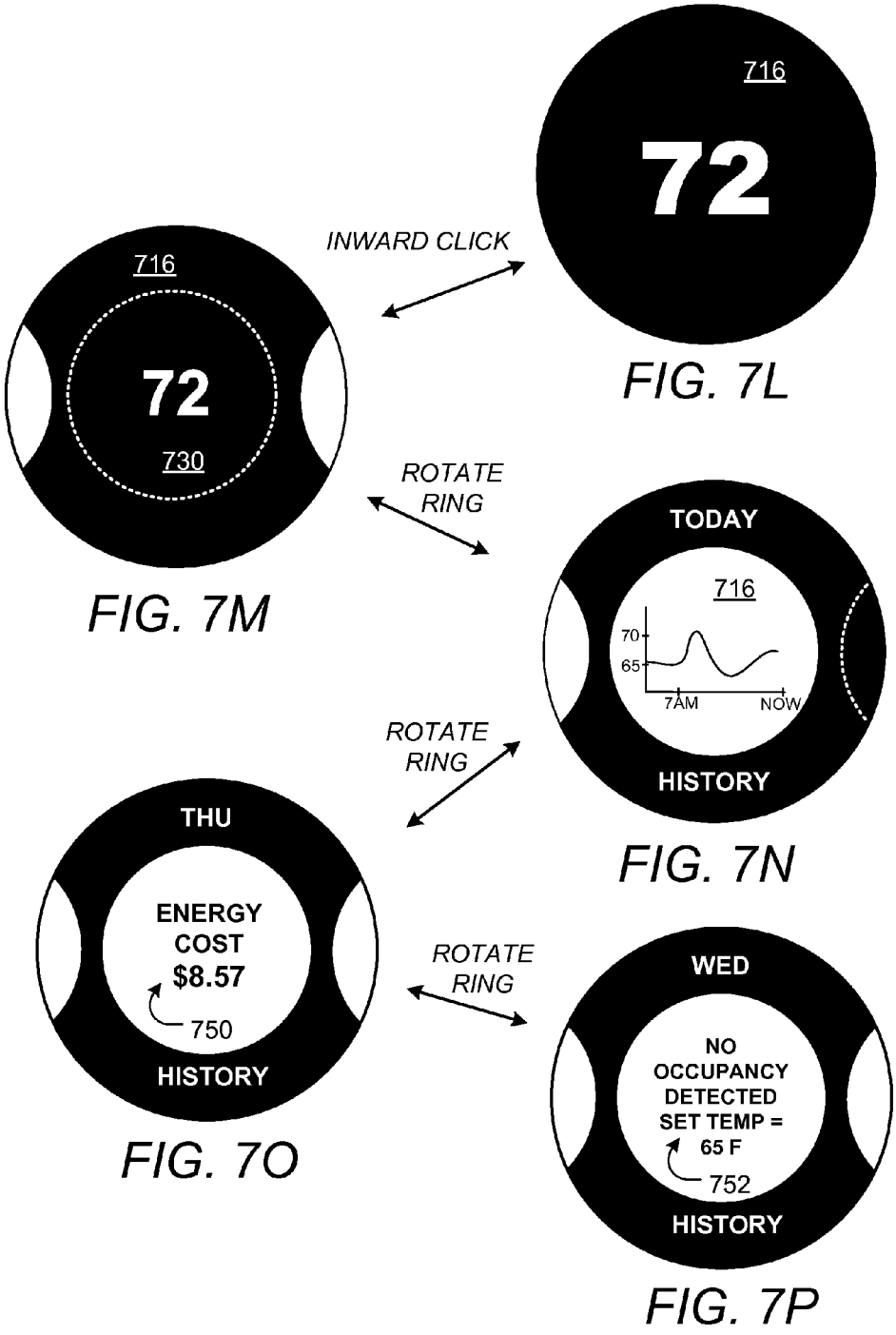


FIG. 7K


716
72
INWARD CLICK
716
72
730
FIG. 7L
ROTATE RING
TODAY
716
70
65
7AM
NOW
HISTORY
FIG. 7M
ROTATE RING
THU
ENERGY COST
$8.57
750
HISTORY
FIG. 7N
ROTATE RING
WED
NO OCCUPANCY DETECTED
SET TEMP = 65 F
752
HISTORY
FIG. 7O
FIG. 7P

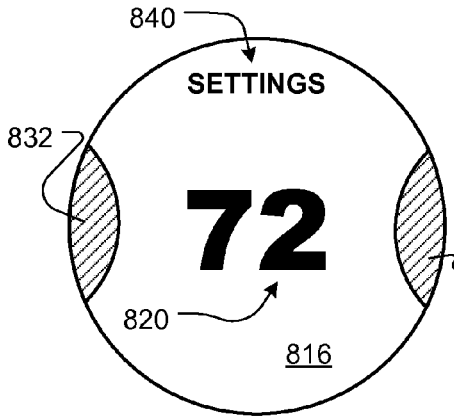


FIG. 8B

PRESS AND HOLD

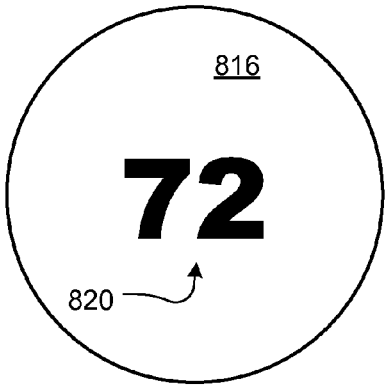


FIG. 8A

ROTATE RING

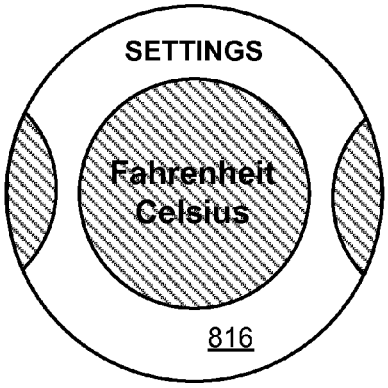


FIG. 8C

ROTATE RING

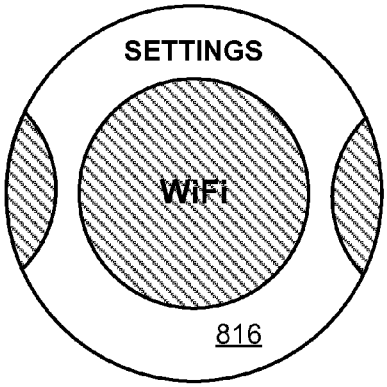


FIG. 8D

ROTATE RING

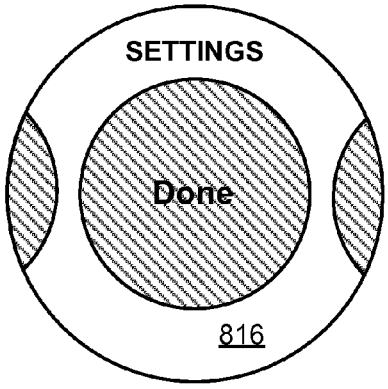


FIG. 8E

INWARD CLICK

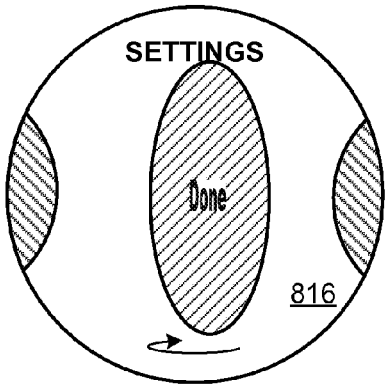


FIG. 8F

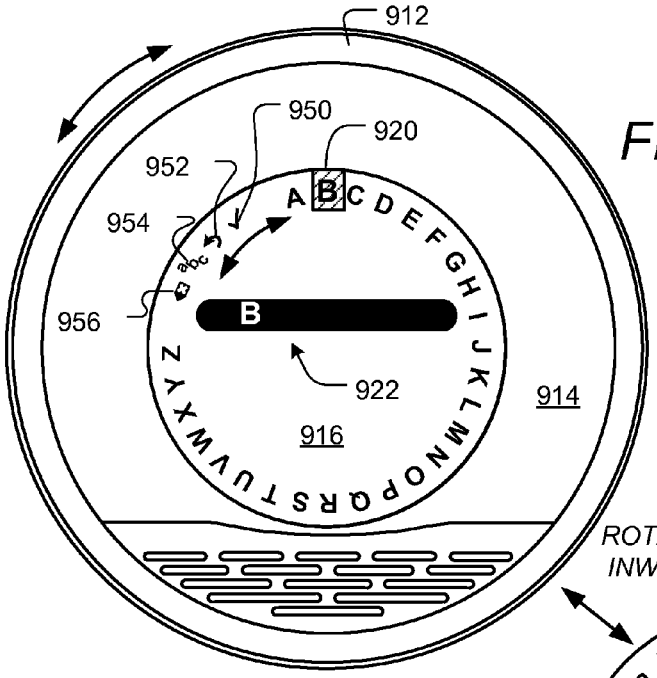


FIG. 9A

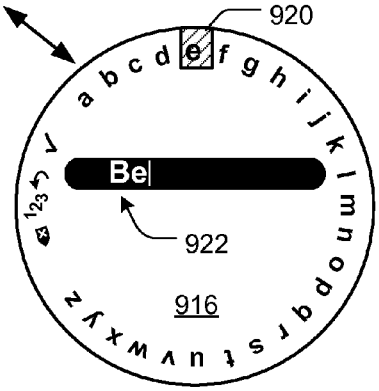


FIG. 9B

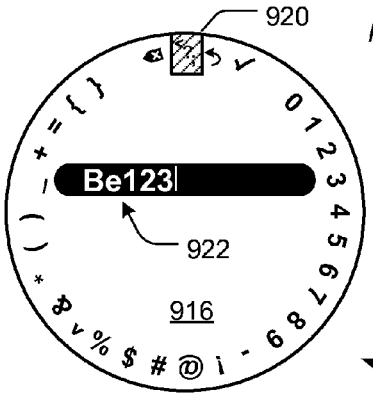


FIG. 9C

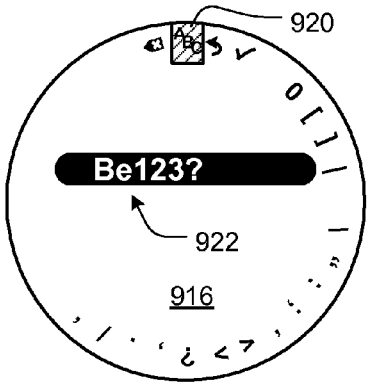


FIG. 9D

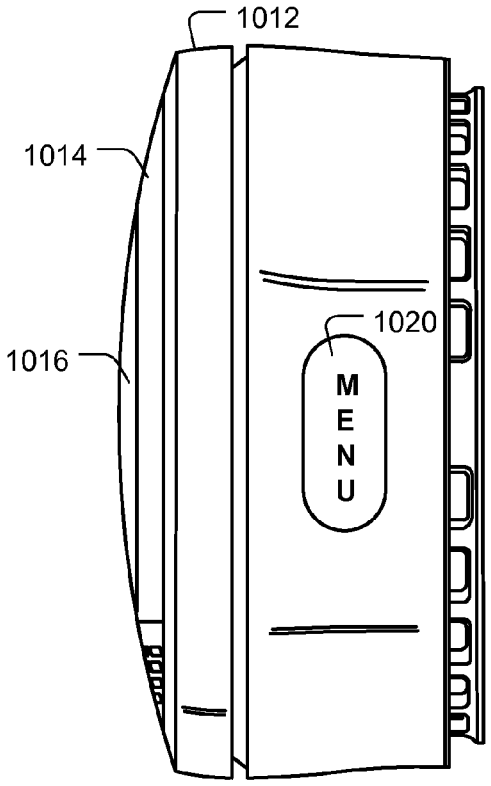


FIG. 10A

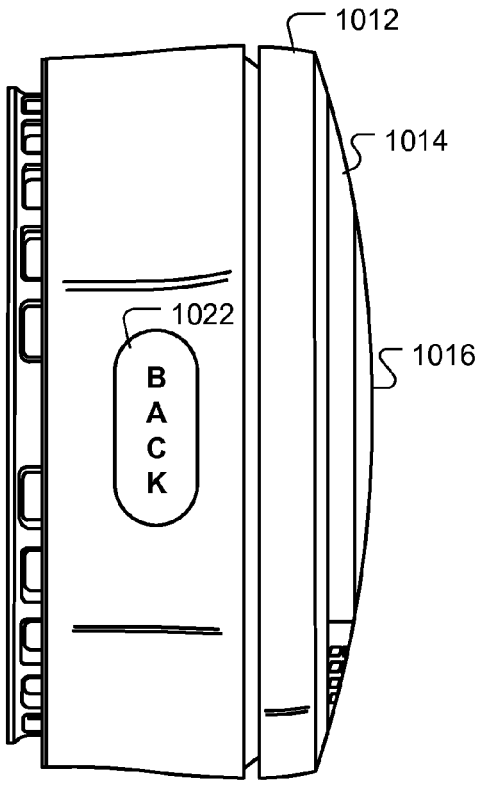


FIG. 10B

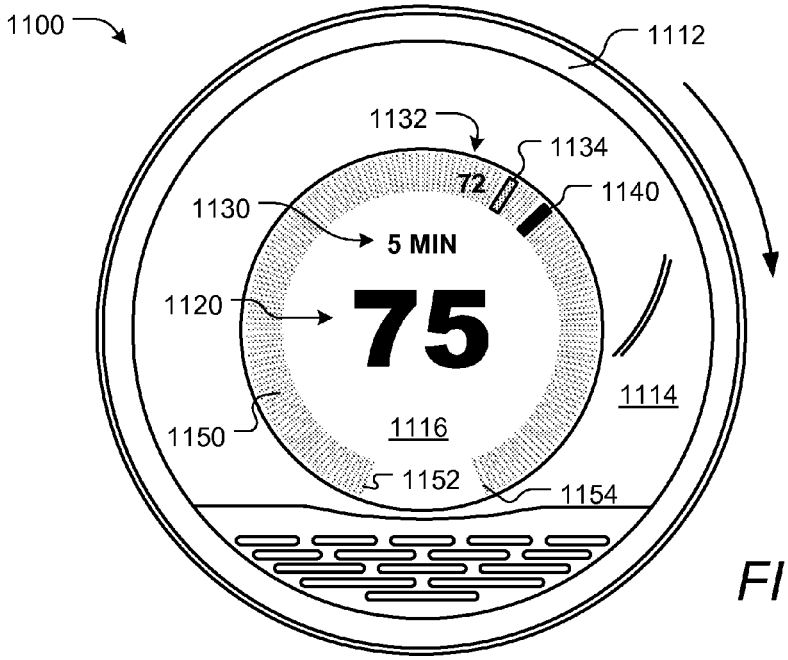


FIG. 11A

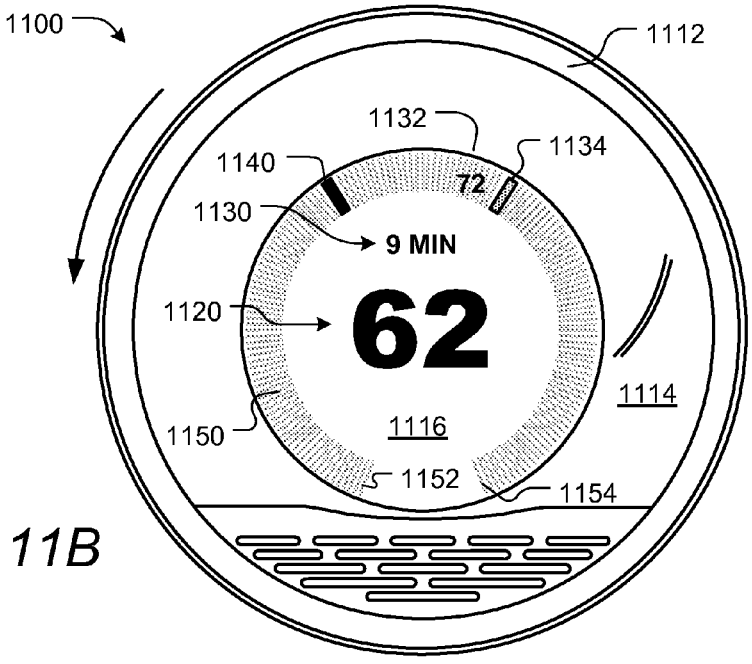


FIG. 11B

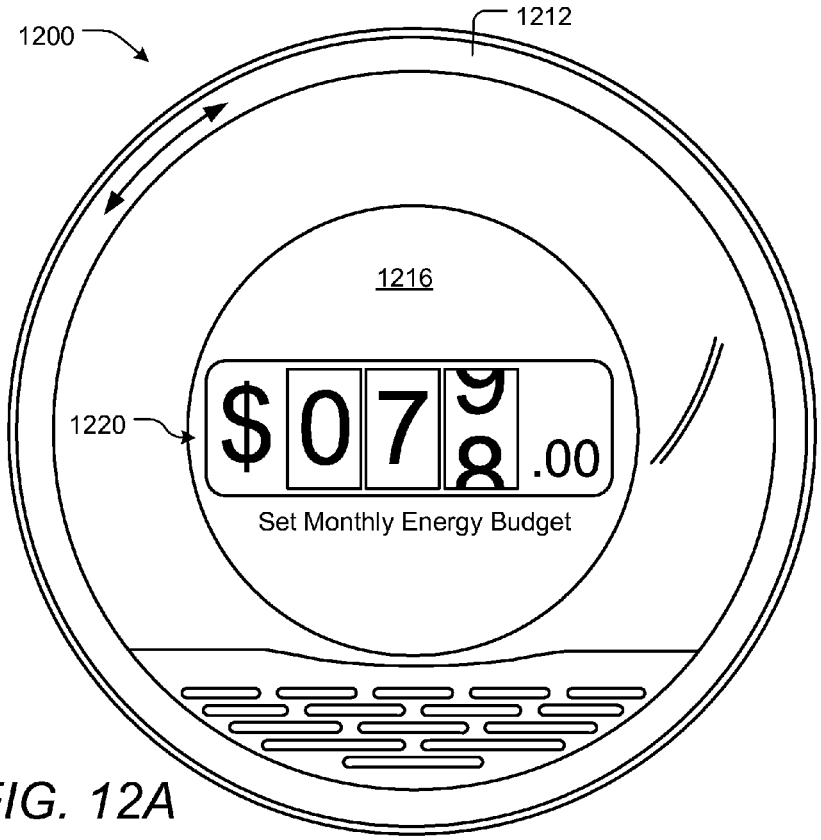


FIG. 12A

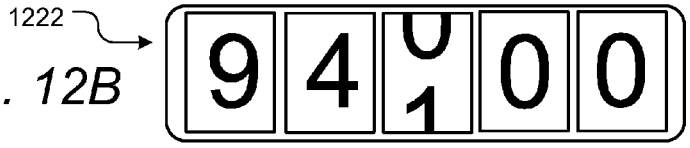


FIG. 12B

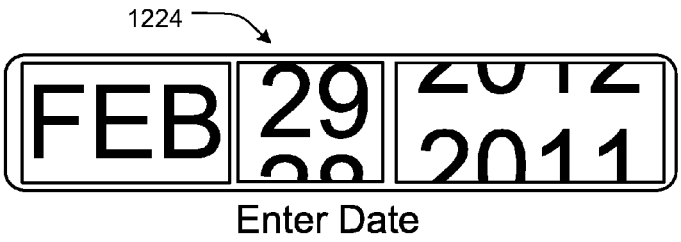


FIG. 12C

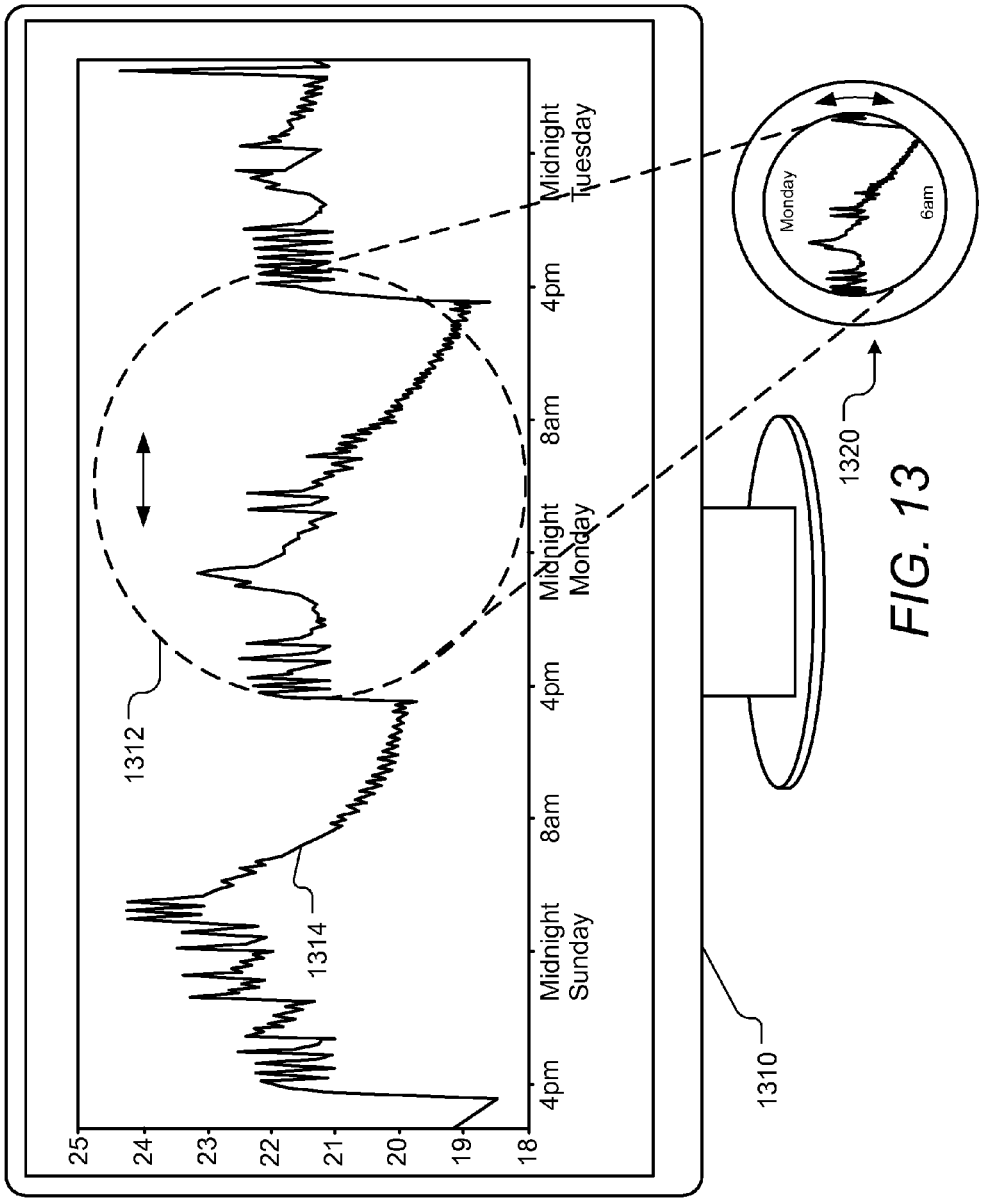

25
24
23
22
21
20
19
18
4pm
Midnight
Sunday
8am
4pm
Midnight
Monday
8am
4pm
Midnight
Tuesday
1312
1314
1310
1320
Monday
6am

FIG. 13

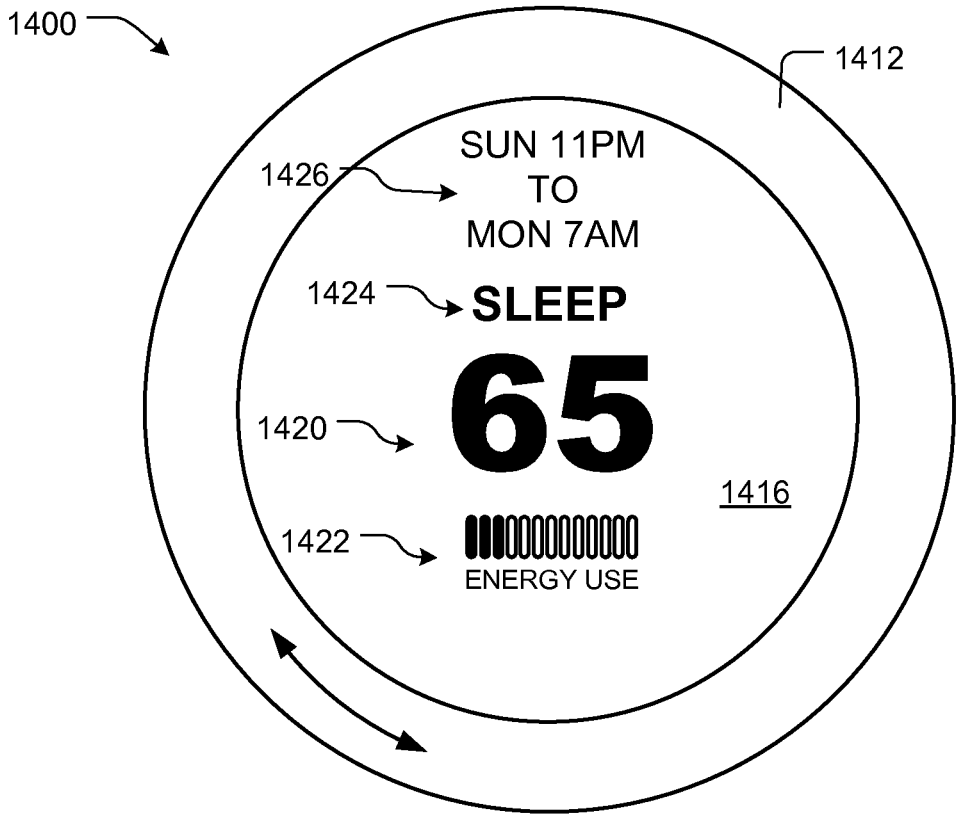


FIG. 14A

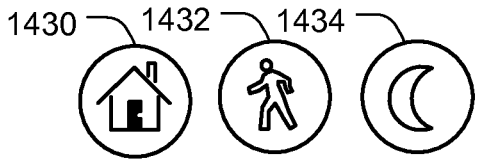


FIG. 14B

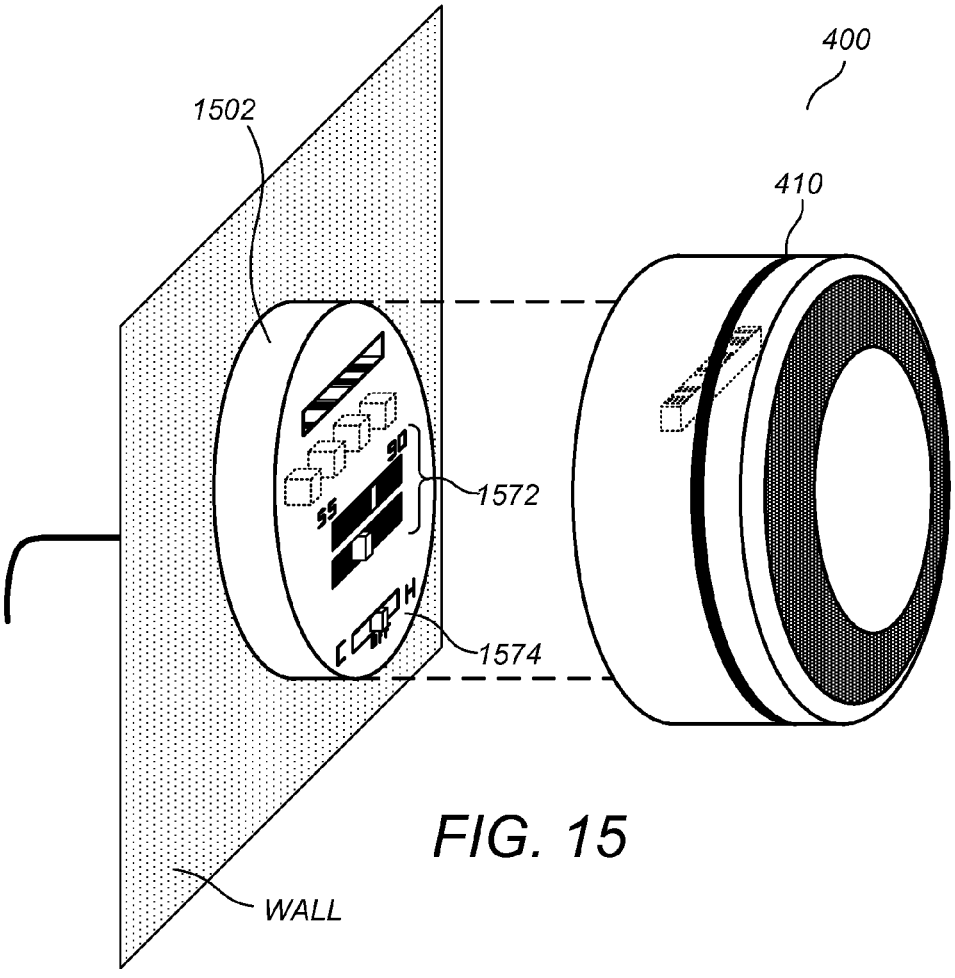


FIG. 15

USER FRIENDLY INTERFACE FOR CONTROL UNIT

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application claims the benefit of U.S. Prov. Ser. No. 61/415,771 filed Nov. 19, 2010; and of U.S. Prov. Ser. No. 61/429,093 filed Dec. 31, 2010. The subject matter of this patent specification also relates to the subject matter of the following commonly assigned applications: U.S. Ser. No. 12/881,430 filed Sep. 14, 2010; U.S. Ser. No. 12/881,463 filed Sep. 14, 2010; U.S. Ser. No. 12/984,602 filed Jan. 4, 2011; and U.S. Ser. No. 12/987,257 filed Jan. 10, 2011. Each of the above-referenced patent applications is incorporated by reference herein.

COPYRIGHT AUTHORIZATION

A portion of the disclosure of this patent document may contain material that is subject to copyright protection. The copyright owner has no objection to the facsimile reproduction by anyone of the patent document or the patent disclosure, as it appears in the Patent and Trademark Office patent file or records, but otherwise reserves all copyright rights whatsoever.

BACKGROUND

This invention relates generally to the control of HVAC systems. More particularly, embodiments of this invention relate to user interfaces for thermostats, other HVAC controlling systems, and/or for other systems for controlling household utilities, resources or other systems.

While substantial effort and attention continues toward the development of newer and more sustainable energy supplies, the conservation of energy by increased energy efficiency remains crucial to the world's energy future. According to an October 2010 report from the U.S. Department of Energy, heating and cooling account for 56% of the energy use in a typical U.S. home, making it the largest energy expense for most homes. Along with improvements in the physical plant associated with home heating and cooling (e.g., improved insulation, higher efficiency furnaces), substantial increases in energy efficiency can be achieved by better control and regulation of home heating and cooling equipment. By activating heating, ventilation, and air conditioning (HVAC) equipment for judiciously selected time intervals and carefully chosen operating levels, substantial energy can be saved while at the same time keeping the living space suitably comfortable for its occupants.

Historically, however, most known HVAC thermostatic control systems have tended to fall into one of two opposing categories, neither of which is believed be optimal in most practical home environments. In a first category are many simple, non-programmable home thermostats, each typically consisting of a single mechanical or electrical dial for setting a desired temperature and a single HEAT-FAN-OFF-AC switch. While being easy to use for even the most unsophisticated occupant, any energy-saving control activity, such as adjusting the nighttime temperature or turning off all heating/cooling just before departing the home, must be performed manually by the user. As such, substantial energy-saving opportunities are often missed for all but the most vigilant users. Moreover, more advanced energy-saving settings are not provided, such as the ability to specify a custom temperature swing, i.e., the difference between the desired set temperature and actual current temperature (such as 1 to 3 degrees) required to trigger turn-on of the heating/cooling unit.

In a second category, on the other hand, are many programmable thermostats, which have become more prevalent in recent years in view of Energy Star (US) and TCO (Europe) standards, and which have progressed considerably in the number of different settings for an HVAC system that can be individually manipulated. Unfortunately, however, users are often intimidated by a dizzying array of switches and controls laid out in various configurations on the face of the thermostat or behind a panel door on the thermostat, and seldom adjust the manufacturer defaults to optimize their own energy usage. Thus, even though the installed programmable thermostats in a large number of homes are technologically capable of operating the HVAC equipment with energy-saving profiles, it is often the case that only the one-size-fits-all manufacturer default profiles are ever implemented in a large number of homes. Indeed, in an unfortunately large number of cases, a home user may permanently operate the unit in a "temporary" or "hold" mode, manually manipulating the displayed set temperature as if the unit were a simple, non-programmable thermostat. Thus, there is a need for a thermostat having an improved user interface that is simple, intuitive and easy to use such that the typical user is able to access many of the features such as programming energy-saving profiles.

At a more general level, because of the fact that human beings must inevitably be involved, there is a tension that arises between (i) the amount of energy-saving sophistication that can be offered by an HVAC control system, and (ii) the extent to which that energy-saving sophistication can be put to practical, everyday use in a large number of homes. Similar issues arise in the context of multi-unit apartment buildings, hotels, retail stores, office buildings, industrial buildings, and more generally any living space or work space having one or more HVAC systems. Other issues arise as would be apparent to one skilled in the art upon reading the present disclosure.

SUMMARY

According to some embodiments a programmable device for controlling an HVAC system is provided. The device is preferably a programmable thermostat and includes a rounded body; a rounded display mounted on the body and adapted to display information to a user; a rotating ring mounted on the body and adapted to receive user input; and a processing system adapted to control one or more HVAC functions according to a scheduled program, to display information on the rounded display and to receive user input from the rotating ring. According to some embodiments the body, display and ring are circular in shape, and the display is a dot matrix display using a display technology such as passive LCD, monochrome LCD, color LCD, organic light-emitting diode, or electronic ink. According to some embodiments different colors are displayed to the user to indicate currently active HVAC functions, and different shades of colors are displayed to a user to indicate an estimated amount of time and/or energy for reaching a target temperature.

According to some embodiments, the rounded body forms part of a head unit, and the device also includes a backplate adapted to be mounted on a wall. The head unit can be removeably mounted to the backplate, and a locking mechanism can be provided for locking the head unit to the back plate so as to increase security against unauthorized removal of the head unit. The backplate can be adapted to be mounted on a wall so as to be level, for example by including a bubble level on the backplate.

According to some embodiments, the rotating ring is mounted so as to be translatably moveable in a direction towards the base of the device so as to receive user input. One or more vents are preferably located on the sides of the body, such as in a gap beneath the translatably mounted ring, and/or in a gap between the head unit and the backplate.

According to some embodiments a method for interacting with a user with a programmable device for controlling an HVAC system is provided. The method includes displaying information to a user on a rounded dot-matrix display mounted on a rounded body of the programmable device; and receiving input from a user at least in part using rotating member mounted on the body and by sensing a translational movement of the rotating member toward the base of the device. The rotating member is preferably a rotating ring surrounding the rounded display. The device can be mounted on a wall on the base of the device.

According to some embodiments, the target temperature for the device can be altered in response to sensing rotation of the rotating ring, and the programmed schedule can be displayed to and altered by the user in response to sensing rotation of the ring and the translational movement of the ring. Historical information such as temperature and cost information can be displayed to a user in response to sensing rotating of the rotating ring. One or more device settings are displayed to and editable by a user in response to sensing rotating of the rotating member and the translational movement. According to some embodiments, text characters are received from a user using the rotating member and the translational movement.

According to some embodiments, a thermostat for controlling at least one HVAC function in an HVAC system is provided. The thermostat includes a back plate and a head unit. The back plate includes connectors adapted to connect to HVAC control wires, and a back plate processor adapted and programmed so as to turn on and turn off the HVAC function. The head unit includes a display adapted to display information to a user, a user input device for receiving input from a user, and a head unit processor adapted and programmed to control the display and processing received user input. The head unit and back plate are adapted to physically attach to each other so as to provide electrical connection between the head unit and back plate. According to some embodiments, the back plate is wall mountable and can include a temperature sensor. According to some embodiments, the back plate can maintain a set temperature when the head unit is not attached to the back plate. According to some embodiments, the back plate can control the HVAC system according to a series of programmed settings that take effect at different times of the day, when the head unit is not attached to the back plate. According to some embodiments the head unit also includes a rechargeable battery, and/or a wireless communication system. According to some embodiments, the head unit can update a thermodynamic model relating to an enclosure in which the HVAC system is installed.

As used herein the term "HVAC" includes systems providing both heating and cooling, heating only, cooling only, as well as systems that provide other occupant comfort and/or conditioning functionality such as humidification, dehumidification and ventilation.

As used herein the term "residential" when referring to an HVAC system means a type of HVAC system that is suitable to heat, cool and/or otherwise condition the interior of a building that is primarily used as a single family dwelling. An example of a cooling system that would be considered residential would have a cooling capacity of less than about 5 tons of refrigeration (1 ton of refrigeration=12,000 Btu/h).

As used herein the term "light commercial" when referring to an HVAC system means a type of HVAC system that is suitable to heat, cool and/or otherwise condition the interior of a building that is primarily used for commercial purposes, but is of a size and construction that a residential HVAC system is considered suitable. An example of a cooling system that would be considered residential would have a cooling capacity of less than about 5 tons of refrigeration.

As used herein the term "thermostat" means a device or system for regulating parameters such as temperature and/or humidity within at least a part of an enclosure. The term "thermostat" may include a control unit for a heating and/or cooling system or a component part of a heater or air conditioner.

It will be appreciated that these systems and methods are novel, as are applications thereof and many of the components, systems, methods and algorithms employed and included therein. It should be appreciated that embodiments of the presently described inventive body of work can be implemented in numerous ways, including as processes, apparata, systems, devices, methods, computer readable media, computational algorithms, embedded or distributed software and/or as a combination thereof. Several illustrative embodiments are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

The inventive body of work will be readily understood by referring to the following detailed description in conjunction with the accompanying drawings, in which:

FIG. **1** is a diagram of an enclosure in which environmental conditions are controlled, according to some embodiments;

FIG. **2** is a diagram of an HVAC system, according to some embodiments;

FIGS. **3**A-C illustrate a thermostat having a user friendly interface, according to some embodiments;

FIG. **4**A illustrates a thermostat having a head unit and a backplate for ease of installation, configuration and upgrading, according to some embodiments;

FIGS. **4**B-C shows a top and bottom view of a thermostat backplate, according to some embodiments;

FIGS. **5**A-B illustrate a thermostat as it is being controlled by the hand of a user according to some embodiments;

FIGS. **6**A-F illustrate basic user interactions with a thermostat, according to some embodiments;

FIGS. **7**A-P illustrate a thermostat having a user interface capable of viewing and editing future set points and review historical information, according to some embodiments;

FIGS. **8**A-F illustrates how other thermostat settings can be made using a user interface, according to some embodiments;

FIGS. **9**A-D illustrate a thermostat having a user interface capable of entering textual information, according to some embodiments;

FIGS. **10**A and **10**B show a thermostat having further buttons to facilitate user input and navigation, according to some embodiments;

FIGS. **11**A-B illustrate further aspects of a user interface for a thermostat according to some embodiments;

FIGS. **12**A-C illustrate aspects of a thermostat user interface, according to some embodiments;

FIG. **13** shows the relationship between a computer display and thermostat display, according to some embodiments; and

FIGS. **14**A-B show a thermostat having an interactive user interface, according to some embodiments.

FIG. **15** illustrates an exploded perspective view of a thermostat having an HVAC-coupling wall dock, according to some embodiments.

DETAILED DESCRIPTION

A detailed description of the inventive body of work is provided below. While several embodiments are described, it should be understood that the inventive body of work is not limited to any one embodiment, but instead encompasses numerous alternatives, modifications, and equivalents. In addition, while numerous specific details are set forth in the following description in order to provide a thorough understanding of the inventive body of work, some embodiments can be practiced without some or all of these details. Moreover, for the purpose of clarity, certain technical material that is known in the related art has not been described in detail in order to avoid unnecessarily obscuring the inventive body of work.

FIG. **1** is a diagram of an enclosure in which environmental conditions are controlled, according to some embodiments. Enclosure **100**, in this example is a single-family dwelling. According to other embodiments, the enclosure can be, for example, a duplex, an apartment within an apartment building, a light commercial structure such as an office or retail store, or a structure or enclosure that is a combination of the above. Thermostat **110** controls HVAC system **120** as will be described in further detail below. According to some embodiments, the HVAC system **120** is has a cooling capacity less than about 5 tons. According to some embodiments, a remote device **112** wirelessly communicates with the thermostat **110** and can be used to display information to a user and to receive user input from the remote location of the device **112**. According to some embodiments, the device **112** can be located outside of the enclosure **100**.

FIG. **2** is a diagram of an HVAC system, according to some embodiments. HVAC system **120** provides heating, cooling, ventilation, and/or air handling for the enclosure, such as a single-family home **100** depicted in FIG. **1**. The system **120** depicts a forced air type heating system, although according to other embodiments, other types of systems could be used. In heating, heating coils or elements **242** within air handler **240** provide a source of heat using electricity or gas via line **236**. Cool air is drawn from the enclosure via return air duct **246** through filter **270**, using fan **238** and is heated heating coils or elements **242**. The heated air flows back into the enclosure at one or more locations via supply air duct system **252** and supply air grills such as grill **250**. In cooling an outside compressor **230** passes gas such a Freon through a set of heat exchanger coils to cool the gas. The gas then goes to the cooling coils **234** in the air handlers **240** where it expands, cools and cools the air being circulated through the enclosure via fan **238**. According to some embodiments a humidifier **254** is also provided. Although not shown in FIG. **2**, according to some embodiments the HVAC system has other known functionality such as venting air to and from the outside, and one or more dampers to control airflow within the duct systems. The system is controlled by algorithms implemented via control electronics **212** that communicate with a thermostat **110**. Thermostat **110** controls the HVAC system **120** through a number of control circuits. Thermostat **110** also includes a processing system **260** such as a microprocessor that is adapted and programmed to controlling the HVAC system and to carry out the techniques described in detail herein.

FIGS. **3**A-C illustrate a thermostat having a user friendly interface, according to some embodiments. Unlike so many prior art thermostats, thermostat **300** preferably has a sleek, simple, uncluttered and elegant design that does not detract from home decoration, and indeed can serve as a visually pleasing centerpiece for the immediate location in which it is installed. Moreover user interaction with thermostat **300** is facilitated and greatly enhanced over conventional designs by the design of thermostat **300**. The thermostat **300** includes control circuitry and is electrically connected to an HVAC system, such as is shown with thermostat **110** in FIGS. **1** and **2**. Thermostat **300** is wall mounted and has circular in shape and has an outer rotatable ring **312** for receiving user input. Thermostat **300** has a large frontal display area **314**. According to some embodiments, thermostat **300** is approximately 80 mm in diameter. The outer ring **312** allows the user to make adjustments, such as selecting a new target temperature. For example, by rotating the outer ring **312** clockwise, the target temperature can be increased, and by rotating the outer ring **312** counter-clockwise, the target temperature can be decreased. Within the outer ring **312** is a clear cover **314** which according to some embodiments is polycarbonate. Also within out ring **312** is a metallic portion **324**, preferably having a number of windows **318**. According to some embodiments, the surface of cover **314** and metallic portion **324** form a curved spherical shape gently arcing outward that matches a portion of the surface of rotating ring **312**, as shown in the side view **3**B.

According to some embodiments, the cover **314** is painted or smoked around the outer portion, but leaving a central display area **316** clear so as to facilitate display of information to users. According to some embodiments, the curved cover **314** acts as a lens which tends to magnify the information being displayed in display area **316** to users.

According to some embodiments central display area **320** is a dot-matrix layout (individually addressable) such that arbitrary shapes can be generated, rather than being a segmented layout. According to some embodiments, a combination of dot-matrix layout and segmented layout is employed. According to some embodiments, central display area **316** is a backlit color liquid crystal display (LCD). According to some embodiments, other display technologies can be used such as passive and/or monochrome LCD, organic light-emitting diode (OLED), or electronic ink (e-ink) display technology. E-ink, that reflects light while not drawing power is particularly well suited, according to some embodiments, since a thermostat typically does not require a particularly short refresh time and also benefits greatly from relatively low power consumption. An example of information is shown in FIG. **3**A, which are central numerals **320**.

According to some embodiments, metallic portion **324** has number of openings **318** so as to allow the use of a passive infrared proximity sensor **330** mounted beneath the portion **324**. Openings **318** are used, according to some embodiments, since many useful materials are opaque to infrared energy in useful wavelengths such as about 10 microns.

Preferably, the outer ring **312** is mechanically mounted in a manner that provides a smooth yet viscous feel to the user, for further promoting an overall feeling of elegance while also reducing spurious or unwanted rotational inputs. According to some embodiments, rotating outer ring **312** rotates on plastic bearings and an optical digital encoder is used to measure the rotational movement and/or rotational position of the ring **312**. According to other embodiments, other technologies such as mounting the rotating ring **312** on a central shaft may be employed.

According to some embodiments, ventilation is facilitated through gap **332** between the rotating ring **312** and the body of the head unit **310**, through gap **344** between the head unit **310**

and the backplate **340**, and into the backplate **340** via vents **342**. In general, air circulation through gaps **332** and **344** and through vents **342** serves two purposes. Firstly, the air circulation allows the ambient air to reach one or more sensors located inside the thermostat. Secondly, the air circulation allows electronics in the thermostat to cool such that heat from the electronics does not significantly effect the sensing of the ambient air characteristics. According to some embodiments, the vents **332**, **344** and **342** are visually hidden from the user as shown in FIGS. **3**A-**3**C, allows for a simple, visually uncluttered design that facilitates ease of use by users.

A locking mechanism is also provided that is engaged via turning the screw head **322** a quarter turn.

FIG. **4**A illustrates a thermostat having a head unit and a backplate (or wall dock) for ease of installation, configuration and upgrading, according to some embodiments. Thermostat **400** is preferably designed as shown in and described with respect to FIGS. **3**A-C. As in the case of thermostat **300**, thermostat **400** is wall mounted and has circular in shape and has an outer rotatable ring **412** for receiving user input. Thermostat **400** has a cover **414** that includes a display area **416**. Head unit **410** of round thermostat **400** slides on to back plate **440**. According to some embodiments the connection of the head unit **410** to backplate **440** can be accomplished using magnets, bayonet, latches and catches, tabs or ribs with matching indentations, or simply friction on mating portions of the head unit **410** and backplate **440**.

According to some embodiments, a locking mechanism is provided wherein a post **450** on the backplate **440** is engaged by a quarter turn of a latch. According to some embodiments a flat head screw head is used for the latch. According some other embodiments other types screw heads can be used to provide greater security such as when the thermostat is being installed in public locations. According to some embodiments, the head unit **410** includes a processing system **420**, display driver **424** and a wireless communications system **426**. The processing system **420** is adapted to cause the display driver **424** and display area **416** to display information to the user, and to receiver user input via the rotating ring **412**, as is described in greater detail herein. The processing system **420**, according to some embodiments, is capable of maintaining and updating a thermodynamic model for the enclosure in which the HVAC system is installed. For further detail on the thermodynamic modeling, see U.S. patent Ser. No. 12/881,463 filed Sep. 14, 2010, which is incorporated by reference herein. According to some embodiments, the wireless communications system **426** is used to communicate with devices such as personal computers and/or other thermostats or HVAC system components.

Backplate **440** includes electronics **482** and temperature sensor **484** in housing **460**, which are ventilated via vents **442**. A bubble level **462** is provided to aid in the correctly orienting the thermostat when mounting on a wall. Wire connectors **470** are provided to allow for connection to HVAC system wires. Connection terminal **480** provides electrical connections between the head unit **410** and backplate **440**.

FIGS. **4**B-C shows a top and bottom view of a thermostat backplate, according to some embodiments. The backplate **440** is mounted on a wall using screws through two openings: round hole **464** and slotted hole **466**. By using a slotted shaped hole **466**, the user or installer can make small adjustments in the angle of mounting of backplate **440**. As shown in FIG. **4**B, backplate **440** includes a bubble level **462** including a window **472** through which the user can check and make a level mounting of backplate **440** on a wall. The HVAC system wires pass through a large rectangular opening **468** and are connected to wire connectors **470**. According to some embodiments, eight wire connectors are provided as shown in FIG. **4**B, and labeled with common HVAC system wire names. FIG. **4**C shows the back of backplate **440**, the side that will face the wall when thermostat **400** is wall mounted. Temperature sensor **484** is includes and allows the backplate **440** to operate as a fully functional thermostat even when not connected to the headunit **410**. For example, the backplate electronics **482** includes an MCU processor, and driver circuitry for opening and closing the HVAC control circuits, thereby turning on and turning off the one or more HVAC functions such as heating and cooling. The electronics **482** also includes flash memory which is used to store the series of programmed settings that take effect at different times of the day, such that the programmed set point changes can be carried out even when the headunit **410** is not attached to the backplate **440**. According to some embodiments, the electronics **482** also includes power harvesting circuitry so obtain power from the HVAC control circuit(s) even when an HVAC common power wire is not available.

The docking capability of headunit **410**, according to some embodiments, provides many advantages and opportunities in both a technology sense and a business sense. Because the headunit **410** can be easily removed and replaced by even the most non-technically-savvy customer, many upgrading and upselling opportunities are provided. For example, many different versions of the headunit **410** can be separately sold, the different versions having different colors, styles, themes, and so forth. Upgrading to a new headunit **410** having more advanced capabilities becomes a very easy task, and so the customer will be readily able to take advantage of the newest display technology, sensor technology, more memory, and so forth as the technology improves over time.

FIG. **15** illustrates an exploded perspective view of the headunit **410** and an HVAC-coupling wall dock **1502** according to an embodiment. The HVAC coupling wall dock **1502**, according to some embodiments, includes a standard temperature readout/setting dial **1572** and a simple COOL-OFF-HEAT switch **1574**, and can function as an elemental, standalone thermostat when the headunit **410** is removed. This can prove useful for a variety of situations, such as if the headunit **410** needs to be removed for service or repair for an extended period of time over which the occupants would still like to remain reasonably comfortable. For one embodiment, the elemental thermostat components **1572** and **1574** are entirely mechanical in nature, such that no electrical power is needed to trip the control relays. For other embodiments, simple electronic controls such as electrical up/down buttons and/or an LCD readout are provided. For other embodiments, some subset of the advanced functionalities of the headunit **410** can be provided, such as elemental network access to allow remote control, to provide a sort of "brain stem" functionality while the "brain" (the headunit **410**) is temporarily away.

FIGS. **5**A-B illustrate a thermostat as it is being controlled by the hand of a user according to some embodiments. Thermostat **500** is preferably designed as shown in and described with respect to FIGS. **3**A-C and **4**A-C. As in the case of thermostats **300** and **400**, thermostat **500** is wall mounted and has circular in shape and has an outer rotatable ring **512** for receiving user input. Thermostat **500** has a cover **514**, which includes a display area **516**. Head unit **510** of round thermostat **500** slides on to back plate (not shown). The head unit **510** includes an upper cap **508** and a main body **506**. The upper cap **508** includes the rotating ring **512**, cover **514** and display area **516**.

According to some embodiments, for the combined purposes of inspiring user confidence and further promoting visual and functional elegance, the thermostat **500** is controlled by only two types of user input, the first being a rotation of the outer ring **512** (FIG. **5**B) (referenced hereafter as an "rotate ring"), and the second being an inward push on the upper cap **508** (FIG. **5**C) until an audible and/or tactile "click" occurs. According to some embodiments, the inward push of FIG. **4**C only causes the outer ring **512** to move forward, while in other embodiments the entire upper cap **508** moves inwardly together when pushed. Preferably, cover **514** does not rotate with outer ring **512**. According to some embodiments, pushing inward of upper cap **508** can include multiple types of user input. A single brief push inward until the audible and/or tactile click occurs followed by a release (single click) can be interpreted as one type of user input (referenced hereafter as an "inward click"). Pushing the upper cap **508** and holding the inward pressure for an amount of time such as 1-3 seconds can be interpreted as another type of user input (referenced hereafter as a "press and hold"). According to some embodiments, other types of input can be interpreted by a user such as double and/or multiple clicks, and pressing and holding for longer and/or shorter periods of time. According to other embodiments, speed-sensitive or acceleration-sensitive rotational inputs may be implemented (e.g., a very large and fast leftward rotation specifies an "Away" occupancy state, while a very large and fast rightward rotation specifies an "Occupied" occupancy state).

FIGS. **6**A-F illustrate basic user interactions with a thermostat, according to some embodiments. Thermostat **600** is preferably designed as shown in and described with respect to FIGS. **3**A-C, **4**A-C and **5**A-B. As in the case of thermostats **300**, **400** and **500**, thermostat **600** is wall mounted and has circular in shape and has an outer rotatable ring **612** for receiving user input, a cover **614** and a display area **616**. Large central numerals **620** are shown in FIG. **6**A, and in this case represent the current temperature. Although in FIGS. **6**A-F the central numerals **620** are shown in black against a white background in display area **616**, according so some embodiments the numerals **620** are displayed in white and the background of display area **616** indicates to a user the HVAC function currently be used. According to some embodiments, displaying a black background in area **616** indicates that the HVAC system is neither currently heating nor currently cooling.

According to some embodiments, a user can change the set point of thermostat **600** by rotating the ring **612**. In the example shown in FIGS. **6**A-F, rotating the ring in a clockwise causes an increase in set point temperature, such as show in FIG. **6**B. In FIG. **6**B, the set point temperature has been increased to 81 degrees in response to the user rotating ring **612** in a clockwise direction. Central numerals **620** display "81" and the text **622** displays "SET TO" to indicate the new current set point temperature. According to some embodiments, after a short period of about 1-5 seconds, the display **616** changes to that of FIG. **6**C. The text **622** changes to "HEATING TO" to indicate to the user that the HVAC heating system is currently being activated. The central numerals **620** remain displaying 81, which is the current set point temperature. The background color in area **616** is changed to indicate the heating function, which according to some embodiments is a shade of red and/or orange. According to some embodiments the color can also be used to indicate the amount of heating that will be required to reach the current set point. For example, more saturated or brighter colors indicate that a greater amount of heating will be required, and more unsaturated or darker colors indicate that a lesser amount of heating will be required. According to some embodiments, the time to reach the set point temperature is displayed textually in text **624** and/or graphically using bars **626**. For further details of calculating and displaying time to reach set point temperature, please refer to U.S. patent Ser. No. 12/984,602, filed Jan. 4, 2011, which is incorporated by reference herein.

According to some embodiments, the display area **616** alternates between showing the current temperature, as in FIG. **6**A, and the set point temperature, as in FIG. **6**C. In this way, when the HVAC system is active, and/or anytime the set point temperature is different from the current temperature, both types of information can be displayed to users. According to some embodiments, the frequency of alternating the displays is about 3-5 seconds.

In FIG. **6**E, the set point temperature has been decreased to 59 degrees in response to the user rotating ring **612** in a counter-clockwise direction from the starting point shown in FIG. **6**D. Central numerals **620** display "59" and the text **622** displays "SET TO" to indicate the new current set point temperature. According to some embodiments, after a short period of about 1-5 seconds, the display **616** changes to that of FIG. **6**F. The text **622** changes to "COOLING TO" to indicate to the user that the HVAC heating system is currently being activated. The central numerals **620** remain displaying 59, which is the current set point temperature. The background color in area **616** is changed to indicate the cooling function, which according to some embodiments is a shade of blue. According to some embodiments the color can also be used to indicate the amount of heating that will be required to reach the current set point. For example, more saturated or brighter colors indicate that a greater amount of cooling will be required, and more unsaturated or darker colors indicate that a lesser amount of cooling will be required. According to some embodiments, the time to reach the set point temperature is displayed textually in text **624** and/or graphically using bars **626**.

According to some embodiments, the display area **616** alternates between showing the current temperature, as in FIG. **6**D, and the set point temperature, as in FIG. **6**F. In this way, when the HVAC system is active, and/or anytime the set point temperature is different from the current temperature, both types of information can be displayed to users. According to some embodiments, the frequency of alternating the displays is about 3-5 seconds.

FIGS. **7**A-P illustrate a thermostat having a user interface capable of viewing and editing future set points and review historical information, according to some embodiments. Thermostat **700** is preferably designed as shown in and described with respect to FIGS. **3**A-C, **4**A-C, **5**A-B, and **6**A-F. As in the case of thermostats **300**, **400**, **500** and **600**, thermostat **700** is wall mounted and has circular in shape and has an outer rotatable ring **712** for receiving user input, a cover **714** and a display area **716** marked by the dotted white circle. Large central numerals **720** are shown in FIG. **7**A, and in this case represent the current temperature. According to some embodiments, in FIG. **7**A, the background of display area **716** is black indicating that the HVAC system is inactive (i.e. neither currently heating nor currently cooling) and numerals **720** are white.

According to some embodiments, the future scheduled program and/or historical information are accessed by the user via a inward click. FIG. **7**B show the thermostat **700** immediately following an inward click. The information that was previously displayed showing the current status, in this case the current temperature of 72 is shrunk down in size as shown by the dotted ring **730** in FIG. **7**B. Note that if the current status had shown current heating or cooling, such as

with colors such as described with resect to FIGS. **6**A-F above, the color and set point temperature would be displayed in the area within dotted ring **730** of FIG. **7**B. The two partial circles **732** and **734** on the left and right sides of circle **730**, respectively, indicate to the user that another screen lies to the left and right that can be accessed via rotating the ring **712**.

FIG. **7**C is a view of display **716** as shown in FIG. **7**B. In response to a ring rotation the program schedule is accessed. FIG. **7**D shows that later today, as indicated by the text **740** "TODAY" at 10 pm, as indicated by the text **742** "10 PM," the set point is scheduled to be changed to 65, as indicated by the numerals **720** "65." Note that the two partial circles **732** and **734** are shown to aid the user in navigation. In the example shown in FIG. **7**D, the left partial circle **732** is shown in black, or whatever color was being used to indicate the current status, as discussed with respect to FIGS. **7**A-C. By rotating the ring further in the same direction (e.g. clockwise), the further programmed set points, shown in FIGS. **7**E, **7**F and **7**G are progressively displayed. By rotating the ring **712** in the opposite direction (e.g. counter-clockwise), progressively earlier programmed set points are displayed.

According to some embodiments the scheduled program can be edited by a user. From any of the displayed programmed set points, such as shown in screen **716** in FIG. **7**H, an inward click is used to indicate the desire to edit the set point. In response to an inward click, the white inner circle **730** expands to fill the display area **716** as shown in FIG. **7**I. The set point temperature indicated by numerals **720** also blinks that indicates to the user the value that will be altered by rotating ring **712**. When the desired set point temperature is set using the ring **712**, another inward click will advance to FIG. **7**J. In FIG. **7**J, the time blinking, and is adjusted using the rotating ring **712**. When the desired set point temperature is set using the ring **712**, another inward click will advance to FIG. **7**K. In FIG. **7**K, the user uses the rotating ring **712** to select one of four choices lists. The selected choice is highlighted in black or a different suitable contrasting color or using an outline. The choices shown in FIG. **7**K are: "DONE" which will accept the changes and take the user back to the displayed schedule screen shown in FIG. **7**H; "ADD NEW SET POINT" which will add a new programmed set point change for the given day; "DELETE SET POINT" which sill delete the current programmed set point; and "CANCEL" which will return the user to the displayed schedule screen without making any changes. According to some embodiments, the thermostat has a predefined number of set points (such as 4 per day=28 per week) which can each be edited as shown in FIGS. **7**I and **7**J, but for simplicity and ease of use, the user cannot add new set points or delete set points.

According to some embodiments, historical information can be displayed to the user as shown in FIGS. **7**L-P. FIG. **7**L shows the display area **716** as in FIG. **7**A. An inward click from a user causes the display are **716** to change to the navigation mode shown in FIG. **7**M which corresponds to display area **716** in FIG. **7**B. By rotating the ring in the opposite direction as would cause the display of future programmed set points (such as shown in FIGS. **7**D-G), a display of historical information can be accessed by the user. According to some embodiments, as shown in FIG. **7**N historical temperature can be displayed in graphical form. For further details on interactively displaying historical information, see FIGS. **13** and **14**A-B.

FIGS. **8**A-F illustrates how other thermostat settings can be made using a user interface, according to some embodiments. FIG. **8**A shows a display area **816** that corresponds to the display area **316**, **416**, **516**, **616** and **716** in the previous figures and as described herein. In FIG. **8**A, the thermostat is displaying a current temperature of 72, for examples using numerals **820**. According to some embodiments, settings are accessed by an inward press and hold of the upper cap of the thermostat. The settings navigation screen shown in FIG. **8**B, following a press an hold, where the current temperature is shown with numerals **820**, two partial circles **832** and **834** indicate to the user that by rotating the outer ring further settings screens can be accessed. The word "SETTINGS" is displayed text **840** to indicate to the user that the settings menu is being displayed. By rotating the ring, various settings can be displayed and edited. For example, FIG. **8**C shows a screen for setting Fahrenheit or Celsius and FIG. **8**D shows a screen for setting WiFi access. According to some embodiments, the particular setting is viewed and can be altered by a press and hold operation while the desired setting type is being displayed. For example, if a user wanted to update the WiFi settings, a press and hold from screen **8**D would cause a display of the current WiFi settings such as the name of the network currently being used, and an option to select a different network and/or enter network security passwords.

According to some embodiments, the settings mode is exited by navigating to the "DONE" screen shown in FIG. **8**E, and then making an inward click. According to some embodiments, the a coin flip transition is used to indicate to the user that a mode is being change, in this case as shown in FIG. **8**F, the coin flip transition indicates the transition from Settings Mode back to current display. Thus, according to some embodiments, transitions between screens can graphically indicated to the user in different ways including: a coin-flip transition (see e.g. FIG. **8**F); a shrinking or growing portion of the display (see e.g. **7**A and **7**B); and a translation or shifting of displayed elements from right-to-left or from left-to-right (see e.g. FIGS. **7**C-G).

FIGS. **9**A-D illustrate a thermostat having a user interface capable of entering textual information, according to some embodiments. Thermostat **900** is preferably designed as shown in and described with respect to FIGS. **3**A-C, **4**A-C, **5**A-B, **6**A-F and **7**A-P. As in the case of thermostats **300**, **400**, **500**, **600** and **700**, thermostat **900** is wall mounted and has circular in shape and has an outer rotatable ring **912** for receiving user input, a cover **914** and a display area **916**. In FIG. **9**A, a screen is shown that allows the user to enter capital letters into the entry window **922** by rotating the outer ring **912** which causes the letters to rotate around the outer area of display area **916**, and when the desired character is positioned within the window **920** the character is selected by a inward click operation. Other than the capital letters: the check mark **950** is used to indicate the text entry operation is finished the selected text should be accepted; the back arrow **952** is used to indicate the text entry operation should be cancelled; a symbol **954** representing another group of characters should be selected for input; and a backspace symbol **956** is used to delete the most recently entered character. FIG. **9**B illustrates the lower case characters, and FIGS. **9**C and **9**D show numbers and various other characters that can be entered.

FIGS. **10**A and **10**B show a thermostat having further buttons to facilitate user input and navigation, according to some embodiments. Thermostat **1000** is preferably designed as shown in and described with respect to FIGS. **3**A-C, **4**A-C, **5**A-B, **6**A-F, **7**A-P and **9**A-D. As in the case of thermostats **300**, **400**, **500**, **600**, **700** and **900**, thermostat **1000** is wall mounted and has circular in shape and has an outer rotatable ring **1012** for receiving user input, a cover **1014** and a display area **1016**. According to some embodiments, the settings screen of FIG. **8**B can be accessed, for example by using an dedicated button **1020** labeled "MENU" or "SETTINGS" or the like as shown in FIG. **10**A. According to some embodi-

ments, the user can reverse the navigation through the various screens and menus by pressing a dedicated button **1022** labeled "BACK" as shown in FIG. **10**B.

FIGS. **11**A-B illustrate further aspects of a user interface for a thermostat according to some embodiments. Thermostat **1100** is preferably designed as shown in and described with respect to FIGS. **3**A-C, **4**A-C, **5**A-B, **6**A-F, **7**A-P, **9**A-D and FIGS. **10**A-B. As in the case of thermostats **300**, **400**, **500**, **600**, **700**, **900** and **1000**, thermostat **1100** is wall mounted and has circular in shape and has an outer rotatable ring **1112** for receiving user input, a cover **1114** and a display area **1116**. FIGS. **11**A and **11**B show further detail of portions of the user interface while the user is adjusting the set point temperature using rotating ring **1112**, according to some embodiments. As in some prior figures, the display **1116** is illustrated with black characters and graphics against a white background for clarity, although according to some preferred embodiments, the characters and graphics are shown in white or some other bright color against a background that is either black or some other color as might be used to indicate current HVAC functionality. When the user rotates the ring **1112** in either direction, thermostat **1100** responds by displaying scale tick marks **1150** around the outer area of display **1116** as shown. According to some embodiments, the tick marks **11150** are shown in decreased contrast with respect to the background, such as decreased brightness in cases there the information is displayed in lighter colors against a darker background. For example, according to some embodiments, the scale ticks **1150** are shown at a brightness value of 75, where a value of 100 represents full brightness. The current temperature is shown by numerals **1132**, and graphically along the tick scale **1150** by current temperature tick **1134**. According to some embodiments, current temperature tick **1134** is wider than the scale ticks **1150** and/or have higher contrast from the background, such as a brightness value of 86 against a darker background. As the rotating ring **1112** is moved by the user in the clockwise direction, the set point temperature is adjusted in an upward direction. The set point temperature is displayed numerically using central numerals **1120** and graphically in the form of a set point tick **1140**. According to some embodiments, the set point tick is wider and/or has even higher contrast than the current temperature tick **1134**, for example a brightness value of 100 against a darker background. Also shown is the estimated time to reach the set point temperature **1130**. Note that the location of the set point tick **1140** depends on the set point temperature, with higher temperatures being represented in the clockwise direction and lower temperatures in the counter-clockwise directions. In FIG. **11**B, the set point temperature is being adjusted to be lower than the current temperature (for example, when the user is calling for cooling rather than heating) in which case the set point tick **1140** is shown to the left of the current temperature tick **1134**. According to some embodiments, the current temperature numerals **1132** is located on the left side of the of the current temperature tick **1134** while heating and on the right side when cooling. Note also that the ends **1152** and **1154** of the scale ticks **1150** can represent the safety minimum temperature and maximum temperature, respectively. According to some embodiments, after a suitable amount of time, such as three seconds, of user inactivity (i.e. no further rotation of ring **1112**), the scale ticks **1150** fade to transparent. Note that although in this example, clockwise is used for higher temperatures and counter clockwise for lower temperatures, according to some embodiment these directions are reversed.

FIGS. **12**A-C illustrate aspects of a thermostat user interface, according to some embodiments. It has been found that the rotating ring user input device is particularly well suited to certain types of interactive display techniques. In particular, according to some embodiments, displaying rotating dials of numbers and/or characters have been found to be particularly useful when obtaining user input for fields of data that are of a fixed character length, and have limited possible characters in each character position. The rotating dial display has been found to give the user positive feedback in terms of quickly finding the correct characters that need to be input. FIG. **12**A shows thermostat **1200** having a rotating ring **1212** and circular display area **1216**. A display **1220** is used for obtaining the user's preference for a monthly budget. According to one embodiment, each of the three dollar numerals individually set using the rotating ring **1212** and then accepted using a inward click. According to another embodiment, the entire dollar amount, that is, all three digits is adjusted at once using the dial. FIG. **12**B shows an example of a display **1222** for entering numerals in a U.S. ZIP code. A similar dial format can be used for combinations of letters and numbers such as are used in other geographic locations. FIG. **12**C shows a date entry display **1224**. Note that according to some embodiments, when the year field is changed from 2012 to 2011, for example, the day number field automatically changes to a valid day number, for example from 29 to 28.

FIG. **13** shows the relationship between a computer display and thermostat display, according to some embodiments. In this example, historical temperature information is represented by curve **1314** and is being displayed to a user on a computer display **1310**. The same information can be viewed by a user on the circular display of the thermostat **1320** using a combination of ring rotation and inward clicks, as is described herein. The historical display can be navigated to by a user as described, for example, with respect to FIGS. **7**L-P. In the case shown in FIG. **13**, the historical temperature data within the window **1312** is shown to the user in the circular display of thermostat **1320**. According to some embodiments, the display shifts to the left and right using the rotating ring and is zoom-able, using a combination of inward click and rotating the ring.

FIGS. **14**A-B show a thermostat having an interactive user interface, according to some embodiments. Thermostat **1400** has a rotating ring **1412** and a circular display **1416** as shown. The display **1416** is being used to display historical information to the user, and can correspond to a screen such as shown in FIGS. **7**N-P. The time period **1426**, set temperature **1420**, relative energy use **1422** and occupancy mode **1424** is displayed as shown. Note that other forms of display can be used, according to other embodiments. For example, in FIG. **14**B, icons **1430**, **1432** and **1434** are used to symbolically display to the user occupancy modes for "home," "away," and "sleep," respectively.

Although the foregoing has been described in some detail for purposes of clarity, it will be apparent that certain changes and modifications may be made without departing from the principles thereof. It should be noted that there are many alternative ways of implementing both the processes and apparatuses described herein. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and the inventive body of work is not to be limited to the details given herein, which may be modified within the scope and equivalents of the appended claims.

What is claimed is:

1. A thermostat, comprising:

a back plate;

a detachable head unit that is configured to be detachably coupled to the back plate;

a processing system that includes a head unit processor included in the detachable head unit and a back plate processor included in the back plate;

a display that is part of the detachable head unit, that is configured to display information, and that is controlled by the head unit processor;

a first user input device that is part of the detachable head unit and that receives user input, which is processed by the head unit processor to control one or more HVAC functions in an HVAC system;

a second user input device that is formed by one or more HVAC controls located the back plate, that is exposed when the detachable head unit is detached, and that enables user input of one or more HVAC settings to be used to control the one or more HVAC functions in the HVAC system when the detachable head unit is detached;

a back plate memory located in the back plate for storing the one or more HVAC settings inputted via the second user input device, which is exposed when the detachable head unit is detached;

wherein, when the detachable head unit is coupled to the back plate, the head unit processor controls the one or more functions in the HVAC system;

wherein, when the detachable head unit is detached from the back plate, the back plate processor controls the one or more HVAC functions in the HVAC system according to the one or more HVAC settings stored in the back plate memory.

2. A thermostat according to claim **1** wherein the back plate is wall mountable.

3. A thermostat according to claim **1** wherein the one or more HVAC settings are programmed settings stored in the back plate memory that take effect at different times of the day.

4. A thermostat according to claim **1** wherein the detachable head unit further includes a rechargeable battery.

5. A thermostat according to claim **1** wherein the detachable head unit further includes a wireless communication system.

6. A thermostat according to claim **1** wherein the head unit is removeably attached to the back plate using one or more types selected from a group consisting of: friction, tab and indentation, magnet, and bayonet.

7. A method, comprising:

receiving, at a detachable head unit of a thermostat, a first input corresponding to an interaction with a first input device of the detachable head unit, the detachable head unit including a head unit processor and a display configured to display information, the thermostat including a back plate that includes a back plate processor and one or more HVAC controls that form a second input device, wherein the second input device is exposed when the detachable head unit is detached so as to enable user input when the detachable head unit is detached;

causing, by the head unit processor of the detachable head unit, at least a portion of the first input to be transmitted to the back plate processor of the back plate;

storing, by the back plate processor of the back plate, at least a portion of the first input in a back plate memory of the back plate of the thermostat;

controlling, by the head unit processor of the detachable head unit, one or more functions in an HVAC system according to the first input;

receiving, at the back plate processor of the back plate of the thermostat, an indication that the detachable head unit has been detached;

controlling, by the back plate processor of the back plate, the one or more functions in the HVAC system according to the at least the portion of the first input stored in the back plate memory of the back plate of the thermostat;

receiving, at the back plate of the thermostat, a second input corresponding to a second interaction with the second input device that is exposed when the detachable head unit is detached, wherein the second interaction occurs when the detachable head unit is detached; and

controlling, by the back plate processor of the back plate, the HVAC system according to the second input;

wherein, when the detachable head unit is coupled to the back plate, the head unit processor controls the one or more functions in the HVAC system;

wherein, when the detachable head unit is detached from the back plate, the back plate processor controls the one or more functions in the HVAC system according to the first or second input stored in the back plate memory.

8. A thermostat back plate that attaches to and communicates with a detachable head unit and that functions as a standalone thermostat when the detachable head unit is detached, the detachable head unit including a display configured to display information, a first user input device configured to receive user input, and a head unit processor configured to control the display, the thermostat back plate comprising:

a second user input device formed by one or more HVAC controls that are exposed when the detachable head unit is detached from the thermostat back plate so as to enable a user to input into the thermostat back plate one or more HVAC settings; and

a back plate processor that detects when the detachable head unit is detached from the thermostat back plate and that controls one or more HVAC functions of an HVAC system according to the one or more HVAC settings inputted via the second user input device of the thermostat back plate when the detachable head unit is detached from the thermostat back plate;

wherein, when the detachable head unit is coupled to the back plate, the head unit processor controls the one or more functions in the HVAC system;

wherein, when the detachable head unit is detached from the back plate, the back plate processor controls the one or more functions in the HVAC system according to the one or more HVAC settings stored in the back plate memory.

9. A thermostat back plate according to claim **8**, further comprising:

a back plate memory that stores one or more HVAC settings and the back plate processor obtains the one or more HVAC settings from the back plate memory.

10. A thermostat back plate according to claim **8** wherein the second user input device is mechanical in nature, such that no electrical power is needed.

11. A thermostat back plate according to claim **10** wherein the second user input device is a setting dial.

12. A thermostat back plate according to claim **10** wherein the second user input device is a COOL-OFF-HEAT switch.

13. A thermostat back plate according to claim **8** wherein the second user input device is electronic.

14. A thermostat back plate according to claim **13** wherein the one or more HVAC controls are one or more electrical up/down buttons.

15. A thermostat back plate according to claim **8** wherein the back plate memory obtains the one or more inputted

HVAC settings from the detachable head unit via a connection terminal when the detachable head unit is attached to the thermostat back plate.

16. A thermostat according to claim **1** wherein wherein the second user input device is mechanical in nature, such that no electrical power is needed.

17. A thermostat according to claim **16** wherein wherein the second user input device is a setting dial.

18. A thermostat according to claim **17** wherein wherein the second user input device is a COOL-OFF-HEAT switch.

19. A method of claim **7** wherein the second user input device is mechanical in nature, such that no electrical power is needed.

20. A method of claim **19** wherein the second user input device is a COOL-OFF-HEAT switch.

* * * * *